E-portfolios rescue biology students from a poorer final exam result: Promoting student metacognition

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Abstract: E-portfolios have the potential to transform students' learning experiences. They promote reflection on the significance of what and how students have learned. Such reflective practices enhance students' ability to articulate their knowledge and skills to their peers, teachers, and future employers. In addition, e-portfolios can help assess the ability of teachers and institutions to inculcate students with their core learning objectives and skills. In 2012/13, I piloted the use of an e-portfolio assignment in a sophomore molecular cell biology course to determine whether it could enhance student learning. My pilot assignment found: 1. The e-portfolio rescued students from a poorer final exam result relative to their midterm exam - students who did not complete the e-portfolio assignment had a greater probability of performing more poorly on the final relative to the midterm exam ($p = 0.004$); 2. E-portfolios can enhance student engagement; 3. Google Sites works well as an e-portfolio platform; 4. Instructors do not need to be technical experts when the e-portfolio platform is embedded in students' everyday digital life; 5. Instructors are able to focus on developing students' learning outcomes associated with e-portfolio assignments when e-portfolios are so embedded; 6. Students may choose whichever e-portfolio platform they prefer, needing only to submit a URL to their e-portfolio for grading.

Keywords: digital life; evidence of learning; Google Sites; independent learner; integrative learning; reflective practice; student engagement; student learning outcomes

INTRODUCTION

Graduating students often have difficulties clearly articulating their learning (Peet et al., 2011). Likewise, some students struggle to apply prerequisite learning to subsequent courses. Both observations indicate that students can have difficulty integrating the significance and applicability of their learning. Some students appear to view education as a series of checkboxes; once a course is checked off a student's list of requirements, students forget what they learned or fail to apply that learning to other educational contexts. E-portfolios may be able to address this situation, as there is evidence that e-portfolios can transform students' learning experiences by heightening student engagement (Herteis and Simmons, 2010) possibly by providing structure for student metacognition (Miller and Morgaine, 2009), which can improve academic performance (Tanner, 2012). E-portfolios provide a structure for students to communicate their learning to others and themselves. Externalizing their learning facilitates students' ability to transfer their learning to simultaneous and subsequent learning experiences (Eynon et al., 2014).

Metacognition has been defined as thinking about one's own thinking or the ability to plan, monitor, and evaluate our own learning processes (Tanner, 2012). Folio-thinking facilitates students' metacognition through the reflective process of collecting evidence of their learning (Chen and Light, 2010), and an e-portfolio publicly displays students' thinking about their learning. The portfolio process promotes higher order thinking (Eynon et al., 2014) by facilitating students' analysis, synthesis, and evaluation of their learning (Herteis and Simmons, 2010). The goal of e-portfolios is to teach students how to learn and improve academic performance (Tanner, 2012), which occurs when students collect evidence of their learning and write about the process used to produce their work. By writing about how they produced their work, students engage in a reflective process which connects their different educational experiences and assesses the benefits of the experience and how it could be improved for the next learning opportunity.

Written reflections within an e-portfolio can transform students' learning by providing a venue for them to consider their thought processes without being trapped by the idea that the correct answer is the only educational goal. Rather, students need to understand that how they problem-solve and think critically is also part of their learning, and focusing solely on the correct answer can sometimes interfere with deeper learning (Tanner, 2012), because they may not consider the process used to arrive at a correct answer. To promote students' consideration of how they think–to improve their critical thinking–instructors need to grade students' thought processes in addition to their final products. Instructors can promote students' reflection by grading students' honest appraisal of their own work and their

articulation of the process used to improve their work. To become independent learners, students need to learn or understand how they think to improve their ability to think (Girash, 2014). Reflection enables students to articulate how they learn, allowing them to understand their ability to connect their learning to their existing mental model (Brown et al., 2014). Reflective thinking – metacognition – is active, directed learning (Rodgers, 2002), and e-portfolios – folio-thinking – are one way to facilitate students' development of their thinking ability. Thinking about learning will facilitate students' assessment of their learning process, and an e-portfolio can enable this by making visible to students their development as a learner (Eynon et al., 2014)

E-portfolios are considered to be a process (workspace) and a product (showcase), while the approach taken when assigning an e-portfolio can be either structured (for institutional assessment) or expressive (students have a choice in what is inserted and use their own voice) (Barrett, 2011). The structured approach enables institutional assessment of its teaching and programs. In contrast, the expressive approach facilitates students' metacognition. E-portfolios can serve both purposes, but the approaches can interfere with each other (Barrett, 2007). Having students develop an e-portfolio with a consideration of how it might be used after the completion of their degree, for example as a showcase for future employers (Kitchenham, 2008), can make students' learning relevant to them (Scott, 2012), as long as it does not interfere with their willingness to post and reflect on developing work (Tosh et al., 2005). This tension between showcase and learning may be solved by giving students control over who is able to view their e-portfolio. Implementation of e-portfolios needs to take this tension between structured showcase and expressed workspace into consideration by determining the primary objective of the assignment beforehand.

The ability for students to make connections within their own education is known to produce deeper learning by producing a more robust knowledge structure (Ambrose et al., 2010). E-portfolios facilitate students' connections between their learning narrative and the artifacts in their digital archive, or between assignments and courses (Herteis and Simmons, 2010), enhancing students' metacognition of their learning (Brandes and Boskic, 2008). In addition, making connections within students' knowledge structure can integrate a sometimes fragmented education (Clark and Eynon, 2009), which can result from students switching programs, institutions, or by students treating courses as islands of learning with no relationship to each other.

Social pedagogy involves students articulating their learning to their peers and external community. As such, social pedagogy can address educational fragmentation by enhancing students' learning through engagement between the learner and the larger community (Eynon et al., 2014). Web 2.0 tools (e.g. Google Sites) enable this connectivity between students, teachers, and the world outside of academia (Tunks, 2012) by facilitating the conversation. From an educational standpoint, Web 2.0 tools enable students to extend the metacognitive conversation they are having with themselves to others through the ability to comment on students' e-portfolios. The social pedagogy possible with e-portfolios can make students' learning visible to both the learner and the community. Articulating to an external community enables the student to express their learning to themselves (Greenstein, 2013).

The advantage of electronic portfolios over traditional portfolios is two-fold: they increase the diversity of artifact possible in a portfolio, and they enable social pedagogy (Lombardi, 2008, Eynon et al., 2014). Increasing the diversity of artifact beyond writing to include photos, drawings, podcasts, and more, requires the application of visual rhetoric (communication through imagery) in e-portfolio construction (Clark and Eynon, 2009) which, similar to written reflections, can affect students' learning. But it is interesting that some students do not understand the advantage of producing an electronic portfolio vs a paper-based portfolio (van Wesel and Prop, 2008), suggesting that students' use of visual rhetoric needs further development.

Part of my interest in developing students' e-portfolio use is to produce deeper integrated learning that sticks. E-portfolios can transform students' learning experiences by integrating rather than compartmentalizing students' courses. Often, students do not link learning that occurs in one course with an educational experience from another course, or from their lived experience. When students complete a pre-requisite course, the aim of instructors is to build upon that prior learning in the subsequent course. Having students record and reflect on their learning in an e-portfolio produces a learning narrative that spans academic terms, and has the potential to enable students' development and integration of their previous learning, which is retained between academic terms and campuses (Clark and Eynon, 2009). Studies demonstrate that e-portfolios develop students' ability to integrate knowledge (Peet et al., 2011). However, the connection between the e-portfolio and the course or program needs to be made explicit to students, making its role in their own learning clear (Wickersham and Chambers, 2006). Explaining to students the integrative role e-portfolios play in education will prepare them to be metacognitive about their own learning, enhancing their level of engagement (Rodgers, 2002) which should produce improved student learning outcomes (Coutinho,

2007, Girash, 2014). The present paper presents the results of piloting an e-portfolio assignment in my sophomore molecular cell biology course, which provides evidence that e-portfolios can improve student learning outcomes.

METHODS

Several issues needed to be considered before I implemented an e-portfolio assignment (Chen and Light, 2010, Chatham-Carpenter et al., 2010, Barrett, 2011, Bass, 2014). First, the focus needs to be on learning the course material; the e-portfolio platform must be sufficiently user-friendly to ensure students do not spend excess energy and time learning the technology. Second, the e-portfolio must be student-centered, giving students the freedom to create a portfolio presence that is representative of themselves, and for which they have control over who is able to view it. Third, the price must be reasonable. Finally, the purpose of the e-portfolio must be clear and distinct (i.e., is it for institutional assessment or for student learning?).

I chose to use Google Sites as the software platform for my e-portfolio assignment because it is freely available and because Gmail is our institutional email system. Thus, Google Sites and Google Drive are already embedded in the educational environment of our students. The ubiquity and familiar interface of Google Sites would facilitate a student-centered experience, which is known to enhance student engagement in the portfolio and thus, also in their own learning (Ring et al., 2008).

The e-portfolio assignment I implemented involved students' reflection on submitted coursework and resulting instructor feedback. This counters the typical student response to instructor feedback, which is to ignore the comments (Wiltse, 2002). The degree to which feedback is ignored is dependent upon the amount of feedback provided, and whether this feedback informs a subsequent assignment or resubmission (Ackerman and Gross, 2010). Students were also tasked with reflecting on how their submitted coursework exemplified their ability to think, research, and communicate; the core academic skills at Augustana (available at http://aug.ualberta.ca/core-curriculum).

Student comments quoted in this study were collected from institutional student evaluations of instruction of my sophomore molecular cell biology course. These comments are completely anonymous, and their use was approved by the university's Research Ethics Board (project #53558). The evaluation includes ten standard institutional questions (available at http://aug.ualberta.ca/USRI). For this particular course, I included the request to "comment on the e-portfolio assignment as an educational experience" on the back of the evaluation form. There were 37 students who completed the molecular cell biology course, of which 20 chose to complete the e-portfolio (the other 17 choose instead to produce a research review poster). There was a gender imbalance in the class (75% female), typical of the biology degree program at Augustana. This gender imbalance was reflected in the number of women (15) who chose to complete the e-portfolio assignment. Seventeen of the 20 students who completed the e-portfolio assignment provided comments on the back of the evaluation form. Due to the completely anonymous nature of the survey, it is unknown which comments are from males and females.

The e-portfolio assignment consisted of six web pages using a template I created for students. Students were able to modify the template to reflect their own experiences, but the basic organization of the web pages within their e-portfolio remained similar for all students. The homepage contained biographical information that students could share (e.g. their major, their interests, what they hoped to do with their degree) plus an introduction to their e-portfolio as evidence of their writing, speaking, thinking, information literacy, and biological skills (the other five web pages). The assignment required that only four of the five skills be addressed. On each of these skill web pages, students provided a hyperlink to their written assignment (in PDF or MS Word format) saved on Google Drive with an accompanying reflection in HTML in their Google Site, indicating why they had chosen the assignment as evidence of their learning. Each of these four assignments researched a different question pertinent to the discipline. This typically involved students commenting on a primary research article, but sometimes also included investigating the accuracy or implications of a newspaper article, radio or TV show, website, or podcast in the area of molecular cell biology. The e-portfolio assignment contributed 15% toward a student's final course grade. Twenty percent of the e-portfolio mark was allocated to the quality of students' reflections and the clarity of its presentation (i.e. visual rhetoric). Forty percent of the assignment mark was allocated to the depth and clarity of a student's chosen investigation. The diversity of artifacts was allocated 20% of the e-portfolio mark, with the remaining 20% allocated for timeliness and mechanics of e-portfolio entries.

RESULTS AND DISCUSSION

Students who did not complete an e-portfolio did significantly poorer on their final relative to their midterm exam (mean ± SE: 61% ± 3.2 vs 70% ± 3.2, respectively, paired t-test, $p = 0.004$, N=17). In contrast, students who completed the e-portfolio assignment had no significant differences between their final and midterm exams (61% ± 3.2 vs 64 ± 3.5, respectively, N=20); there were also no

significant differences between the e-portfolio and poster cohorts' marks or exams. It appears that the e-portfolio assignment rescued students from a poorer result on the final exam (Figure 1). Students typically perform poorer on the final compared to the midterm exam in other courses I have taught over the last 25 years (Figure 2), perhaps due to the greater amount of material examined on comprehensive final exams. This result of rescuing students from a poorer final exam mark may be due to the increased reflection on why and how students are learning in the particular course.

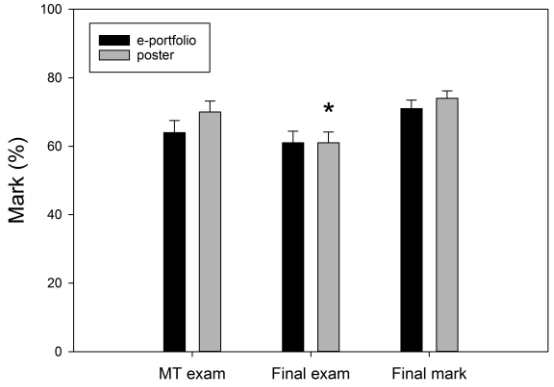

Fig. 1. The impact of the e-portfolio assignment on student learning outcomes in a sophomore molecular cell biology course. Paired two-tailed t-test detected significant differences (* $p = 0.004$) between the midterm (MT) and final exams of students completing the poster assignment ($N = 17$). There were no significant differences between the MT and final exam scores (% mark) of students completing the e-portfolio ($N = 20$) or between the e-portfolio and poster students' exams or final mark.

Overall, the e-portfolio assignment was well received by students, as indicated by student comments on their end of term evaluations of the course:

- "The ePortfolios were a useful educational activity."
- "e-portfolios helped increase my knowledge of topics in this course."
- "Portfolios developed my writing skills and searching along with my citing skills."
- "ePortfolio helped me connect my learning to the real world and encouraged out of class research!"
- "This is what linked my learning to my environment."
- "The eportfolio was interesting, helped with deeper learning and understanding."

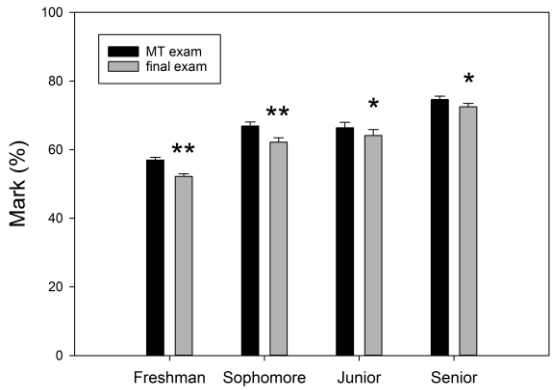

Fig. 2. Student performance (% mark) on midterm (MT) vs final exams in freshman ($N = 633$), sophomore (cell biology pre-e-portfolio assignment, $N = 161$), junior (histology, $N = 94$) and senior (capstone, $N = 138$) biology courses taught by the author since 1990. Paired two-tailed t-test detected significant differences (* $p < 0.05$, ** $p < 0.01$) between the MT and final exams for each year.

Many students thus seemed to understand its significance to them, with some students continuing to use it. In contrast, others felt it was an unnecessary addition to the course requirements (e.g. "…time consuming and pointless") and did not understand what the e-portfolio was accomplishing (e.g. "…not exactly sure what is required"). In addition, some of the students counterbalanced their positive comments with a negative comment, indicating that the e-portfolio assignment was useful for integrating learning from other courses (e.g. "…make me analyze more of my other work") but not necessarily in the course in which the e-portfolio was assigned (e.g. "…didn't enhance my learning in this course").

Student responses which indicated a lack of understanding of the point of e-portfolios (e.g. "…did not find them very educational") are interesting because both the role and utility of e-portfolios were explained to students a number of times throughout the pilot; some students received the instructor's framing of e-portfolios (e.g. "…connect my learning to the real world…") whereas others did not (e.g. "…did not see the point of making it web-based"). This lack of understanding may reflect the distinction between students who were successful in reaching a metacognitive level as opposed to those students who were unable or unwilling to think about their thinking and learning, and the role of making their learning public. Such a distinction has been previously noted: Metacognition must be explicitly part of any active learning pedagogy, otherwise, students may be engaged in the hands-on activity without engaging in their own learning (Tanner, 2012).

My implementation of an e-portfolio assignment suggests, therefore, that to be successful, the context of any e-portfolio assignment must be designed to

align with students' goals and values (Ambrose et al., 2010). This close alignment requires a class discussion to ensure that students' and instructors' understanding of what and why they are teaching and learning are the same.

Four examples illustrate how e-portfolios impacted students. When I first discussed the e-portfolio assignment with the class, I was surprised when students indicated that they did not realize that implicit in their degree was the development of thinking, communication, and research skills. By finding examples of these skills in their coursework, and commenting on how these course products exemplified their proficiency, students became engaged in what, why, and how they were learning. Asking students to consider what, why, and how they learned increased students' awareness of their learning. Others have shown that using a metacognitive activity improved student learning outcomes (Mynlieff et al., 2014) and that metacognition positively correlates with student achievement (Coutinho, 2007).

In another example, a student used the instructor-feedback that their research was superficial, not even having consulted their textbook index. Subsequently, the student chose to reflect on this as a learning opportunity, using it to develop the skill of checking assumptions with deeper research. Students often ignore the feedback provided by the instructor (Wiltse, 2002, Ackerman and Gross, 2010). The e-portfolio assignment, in contrast, required that students directly address the feedback indicating what needed to be improved, and demonstrate the application of the feedback in a subsequent assignment.

In a third example, it was gratifying when, without encouragement on the instructor's part, a student included an assignment from another course to demonstrate their research skills, illustrating how e-portfolios can enable students' integration of their learning across courses within their degree program (Clark and Eynon, 2009). In contrast, we have observed that some students in courses that did not use e-portfolios were unable to apply their learning from a previous or contemporaneous course. Not all students completing an e-portfolio will make these connections, and some students who have not completed an e-portfolio do integrate their education. The point is not that e-portfolios will solve all students' difficulties in integrating their learning: It is that e-portfolios provide a valuable and explicit venue for students to make these connections within their education.

Finally, another student was able to use their e-portfolio after the course in an application for a research position using it to showcase their writing and research skills (Kitchenham, 2008). In this context, there was no tension between showcase and workspace (Tosh et al., 2005), because the student initially designed their e-portfolio specifically to meet the objectives of the course assignment without having to consider whom else might view it, because the student was in control over who was able to access it. It was not until the following year that the student realized their e-portfolio could be used in their application, and thus granted permission to the researcher to view the e-portfolio in order to assess the student's research potential.

I found that I could not assume that students are technologically proficient (Parker et al., 2012). Most students are familiar with Facebook, but not with website design. Google Sites alleviated this problem given the familiarity our students had with the Google interface, since Gmail is our institutional email system. I developed a small repository of website URLs soon after the implementation of the e-portfolio assignment when I realized that some of my students needed assistance with the technical aspects of the e-portfolio platform. This repository alleviated the need for instructors to be technical experts. Students are easily able to find online solutions to their e-portfolio questions given the ubiquity and free availability of Google Sites.

One of the advantages of using Google Sites is that students can choose or design their own website, enhancing their ability to express their own unique educational experience. This was certainly apparent in the different details that students included in their e-portfolio, and how they were arranged on their web pages, even when students used the standard template I provided. The ability for students to design their own website enhances the student-centered character of e-portfolio pedagogy, thereby increasing student engagement (Ring et al., 2008). However, as already stated, not all students are technologically adept, and thus may require support in the creation of their e-portfolio. The website template I provided gave structure for students requiring such assistance; a prepared template is also necessary if instructors desire a particular format for e-portfolios. However, in this pilot study, students required little training or technical assistance with Google Sites, because this particular website platform was already integrated with students' institutional email, calendar, and digital archive. In addition, the available online resources for both designing and developing students' personalized e-portfolios are considerable. Thus, I did not have the same technical difficulty in implementing the e-portfolio platform as has been reported elsewhere (Kitchenham, 2008, Chatham-Carpenter et al., 2010).

I found it interesting that, although the objective of the e-portfolios was reiterated a number of times throughout the term, some students still focused on the mark rather than the learning process (e.g. "… [the e-portfolio] is such a small part that it is insignificant compared to the rest of the class"). This may have resulted from how the assessment criteria

were explained to students; it is imperative that instructors are clear about the criteria for the assignment, so that students understand the basis of their final mark and how it aligns with students' learning goals (Ambrose et al., 2010).

In addition to being clear about the learning objectives and grading criteria for an e-portfolio assignment, providing students with leading questions to guide them with their critical self-reflection also helps orient students to the uses and processes associated with the production of an e-portfolio. Students are typically unaccustomed to the reflective process required for metacognition of their learning. Leading questions can help scaffold students' construction of their e-portfolio and the resulting metacognitive activity that results in deeper learning (Brandes and Boskic, 2008); students need explicit prompting to enable their metacognitive process (Girash, 2014). I developed a series of questions (Haave, 2014) in consultation with colleagues about my e-portfolio assignment to engage students' metacognition about their learning, framed in terms of developing students' learning philosophies (Herteis and Simmons, 2010). Lists of metacognitive prompts for a variety of learning contexts have been published (Herteis and Simmons, 2010, Tanner, 2012, Rafeldt et al., 2014). These questions help students reflect on their course assignments, considering what, why, and how they were learning. My overall objective in the development of these metacognitive prompts for students is to deepen their engagement with the course material, producing an educational experience that will go beyond the confines of the particular assignment or course, integrating their learning between courses and across disciplines (Clark and Eynon, 2009).

A number of issues that arise with e-portfolios have been raised elsewhere (Lorenzo and Ittelson, 2005, Abrami et al., 2008, Chatham-Carpenter et al., 2010, Parker et al., 2012) that are solved by the use of Google Sites. Because Google Sites is integrated with Google Drive, institutions do not need to worry about storage on their own servers. In addition, it is clear that students own the e-portfolio and control access to it, because the website is registered to students' own Gmail account. Although privacy issues have been raised with Google Apps (Rotenberg and Barnes, 2013), the emerging consensus seems to be that social media are inherently public (Hastings, 2010), and thus users should place on the web only material that they would be comfortable reading in a public news forum. The implementation of Google Apps at the University of Alberta places control of what student information resides with Google in students' hands.

Cognitive overload for students learning how to use Google Sites is limited, because the graphical user interface does not require a knowledge of HTML coding, and is familiar to those who use Google Apps: Students are able to focus their attention on their reflective learning rather than on learning the technology. Additionally, instructors can focus on pedagogy rather than technology by directing students to online resources. The abundance of templates and inherent design flexibility of Google Sites enables students to develop an e-portfolio that is their own and not externally imposed. Furthermore, the e-portfolio is portable – it is possible for students to transfer their material over to a Google account if they no longer wish to have it attached to their institutional account. Finally, Google Sites is freely available.

The results of my e-portfolio implementation suggest that faculty be encouraged to consider using e-portfolios in their courses and degree programs as a teaching strategy that enables students' self-reflection on the skills and knowledge gained during their studies. However, I think it would be difficult to implement e-portfolios on an institutional basis because they are a pedagogy (Peet et al., 2011, Eynon et al., 2014); it does not seem right to insist that instructors teach a particular way, when teaching is best when it arises from an instructor's personal identity rather than being imposed by administration (Tanner, 2011). In addition, students should be encouraged to use whatever platform best suits them. Our role as academics is not to train software use, but rather to enable students' metacognition. Embedding e-portfolios in students' everyday online work environment limits the need for technological intervention on the part of instructors. In the end, instructors simply need to instruct their students in metacognitive practice and receive from students the URL to their e-portfolio.

My pilot clearly provides evidence of the positive impact e-portfolios can have on student learning outcomes, in this case, by rescuing students from a poorer final exam result. This impact on student learning outcomes may be due, in part, to their ability to enable connections among students' learning and lived experiences, and its ability to engage faculty in high-impact educational practices (Eynon et al., 2014). Thus, e-portfolios have the potential to transform students' learning experiences by influencing how students engage in their education and by impacting the teaching strategies employed by faculty (Miller and Morgaine, 2009).

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