E-Portfolios for Developing Transferable Skills in a Freshman Engineering Course

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Abstract

Reflective thinking and learning skills are essential for engineers in the knowledge economy. This paper describes an approach to develop these and other transferable skills through individual and collaborative reflective learning using an open-source software. The learning activities and open-source e-portfolio system called *Dotfolio* were trialed by freshman engineering students. Findings from a survey-based study, which investigated students' beliefs about reflective learning and their expectations and experiences related to the task and open-source tool, are reported. From the beginning of the semester the students understood the significance of reflective learning and chose to engage with the tool. However, they were less positive about the collaboration with peers during this activity. At the end of the semester, students were significantly more positive about the tool, but even more negative about the collaboration. The main problems encountered by the tutors and learners were plagiarism and a tension between the privacy of students' reflections and knowledge sharing. The open-source modular architecture allowed for the use of student and tutor feedback for the addition of new features that addressed their concerns.

Index Terms

e-learning, higher education, undergraduate level, engineering, reflective learning, open-source, e-portfolio.

I. Introduction

Since the late 1970's there has been an increasing emphasis on transferable skills in Engineering Education. The IEEE Model Curriculum [1], among others, recommends an increased emphasis on transferable skills such as interpersonal and communication skills. Trautman's seminal paper [2] recommends looking into the dynamics of self and mediated learning (particularly using interactive computer-supported methods) and defines teaching as a stimulation of students' learning rather than as a process of transferring content. Trends in job markets show that universities must prepare future engineers to function in a changing cultural, economic and social environment [3] and that lifelong learning capabilities are essential to all workers in the knowledge-based economy [4]. Engineering programs are frontrunners in the adoption of ICT-based learning, and online technologies are used extensively for delivery of graduate and undergraduate courses [5]–[7]. However, the majority of ICT-based courses are based on traditional pedagogical approaches and are mostly limited to the development of discipline-specific skills [6]. The evidence that ICT-based leaning methods and tools are used for the development of transferable skills, such as independent and collaborative learning capabilities and reflection, is limited [8]–[10].

To develop students' transferable skills, particularly reflective thinking and learning competencies, an electronic portfolio tool – called *Dotfolio* – was designed, implemented and released as open-source [11]. The tool has been in use by three cohorts in a first year Professional Engineering course at the University of Sydney. Several other open-source portfolio tools have recently been developed, such as Moodle's portfolio module and notably the Open-Source Portfolio Initiative (OSPI). E-portfolios have also been added to commercial e-learning systems, such as Blackboard. The designs of different tools have often been based on different pedagogical assumptions, thus placing the emphasis on specific software functionalities. This paper describes the pedagogical goals of Dotfolio, and how this tool has been used to support the development of individual and collaborative reflective learning skills.

A basic tenet for developing e-learning systems is that they must improve students' learning experience. In order to improve the tools and strategies used for e-learning, teachers and developers need reliable feedback. Educators and developers are increasingly sharing their experiences with the community (via online forums, bug reports, etc.). This collaboration has been particularly successful in open-source projects. However, there are several large gaps in research-based evidence about the effectiveness of computer-supported learning. As Goodyear et al. [12] argue, the value of ICT-based learning is well understood by educators. However, it is little known, what students think about its relevance and importance. In addition, the majority of studies on ICT-based learning are based on the data collected at the end of courses. Very little is known about what students think and expect from their studies at the beginning, and how, by the end of a course, students' learning experiences have differed from their initial expectations. In order to improve tools, developers need broader evaluations that consider all aspects of the entire learning process.

This paper examines students' beliefs, expectations and experiences pertaining to reflective learning. Dotfolio is evaluated in the context of its pedagogical aims as a tool for individual and collaborative reflective learning. Using survey data, changes in students' attitudes about reflective learning, task and e-portfolio tool during the semester are explored and potential reasons for these changes are investigated. Then, teachers' feedback about Dotfolio is discussed. Finally, it is showed how a broader survey-based research and teachers' feedback were used to inform open-source software development.

The paper is structured in six sections. Section II reviews the pedagogical rationales for the development and integration of Dotfolio into the engineering program. Section III outlines the conceptual foundation that supports the main technological features implemented in Dotfolio. Section IV presents the method of the accompanying evaluation study. Section V reports results, and Section VI discusses the implications and presents conclusions, giving particular attention to the advantages of using open-source software for this project.

II. Transferable Skills and e-Portfolios

Transferable skills, also known as "generic skills" or "graduate attributes", include such capabilities as: (a) learning, thinking and adaptability; (b) enterprise, innovation and creativity; (c) work readiness and work habits; (d) interpersonal skills and (e) autonomy, personal mastery and self-direction [4]. This project has focused on the pedagogical strategies and software tools that support the development of three main skills: lifelong learning, individual reflective thinking and collaborative reflective thinking.

A capacity and willingness for **lifelong learning** is central to any definition of transferable skills. "Fostering generic skills requires active learning strategies in which learners take responsibility for their own learning so that they develop the attitudes, habits and skills of motivated lifelong learners and the acquisition of generic skills becomes a lifelong learning process" [3].

Reflective thinking is acknowledged as one of the most important aspects of learning and knowledge building in professional practices [13]. As defined by Yancey [14] reflective thinking is "a process by which we think: reviewing, as we think about the products we create and ends we produce, but also about the means we use to get to those ends; and projecting, as we plan for the learning we want to control and accordingly manage, contextualize, understand" (p. 11). From a narrower perspective, reflection is thinking about one's own learning process. From a broader perspective it can include thinking about anyone's thoughts.

When the reflective learning strategy uses other people's thoughts, students can also engage in a **collaboration process**, which makes reflection not only intellectual, but also an affective activity. The ICT-based learning activities aiming to support reflective thinking range from students engaging in structured and guided discussions about selected readings in online forums [8], to students being asked to write personal experiences using blogs [15], [16] or wikis [10], but with little to no structure or guidance. However, the development of e-learning environments that effectively support students' reflective practices remains an open research question that requires more evidence on how these environments affect students' perceptions and approaches to learning [17], [18]. In order to engage in a social reflective discourse with peers and tutors, students need learning tasks, assessments and system functionalities that integrate personal reflections with collaborative knowledge co-construction [17], [19].

Assessment can have an important impact on student interest in learning. Portfolios of students' works have often been used to show evidence of students' skills. Portfolios can be seen as collections of information in the form of various physical or digital artifacts (e.g., documents, video and audio) and may also contain individual reflections on these artifacts [20]. A clear difference is often seen between "showcase portfolios" that are primarily used for accountability and other summative assessment purposes, and "learning portfolios" that are primarily used to support a learning process, and personal or professional development [21].

The potential of learning e-portfolios to support the development of reflective lifelong learning skills encourages their use in formal learning activities. When e-portfolios are used for assessed components of large courses, software must offer two main functionalities: (a) integration of showcase and learning portfolio features and (b) teaching support for effective class management and assessment.

The EduTools benchmarking of seven e-portfolio systems shows that most well-known commercial e-portfolios offer complex, elaborated environments that support learning and showcase [22]. Yet, these systems lack simple functionalities (e.g., blogging) to support easy peer and tutor feedback. They do not contain sufficient functionality for the management of large classes or effective formal assessment of course assignments. The pedagogical goals of this project relied on functionalities like these, which led to the creation of Dotfolio.

III. The Dotfolio System

A. Features

Dotfolio was designed to support the pedagogical goals described earlier offering a number of functionalities, each directly mapped to at least one of these goals. Functionalities included the following:

A repository for archiving and managing digital learning resources and artifacts that are essential for a lifelong learning. Students can upload files, link to resources located on the Internet, organize resources into folders and make them visible to teachers, peers, the external public, or keep them private for personal use. An artifact in the repository can be any digital resource that students find useful for their learning and want to use for reference and/or reflection.

A writing environment where students can record reflections on a specified topic. The system provides a blog system, in which student postings are presented chronologically, with the simple structure of a learning journal. The main technical features of blogs include browser-based authoring tools for creating new web pages and linking them to resources in the repository. This functionality provides an excellent method for creating and organizing conceptual artifacts on the web and supports reflective writing.

A collaboration tool that supports knowledge co-construction. Blogging is generally "individualistic" rather than a "collaborative" activity [23]. However, blog technologies do provide functionalities for exchanging ideas, knowledge sharing and co-construction. In Dotfolio, teachers and other students can comment on each other's entries in the reflective journal, link someone else's entry to their own and "trackback" to other journals that refer back to their entries. Using these features students can engage in a meaningful exchange of ideas and collaborative reflection about topics studied.

A social networking tool that supports interaction and affective learning practices in a professional community. Dotfolio can help students to discover others with similar interests. Each student can customize their portfolio homepage, upload a photo, describe interests, professional background, etc. The content of these pages is then indexed by a site-wide search engine and students can easy find people they can relate to. Then students can subscribe to notifications to stay informed by e-mail about all new journal entries posted by their peers.

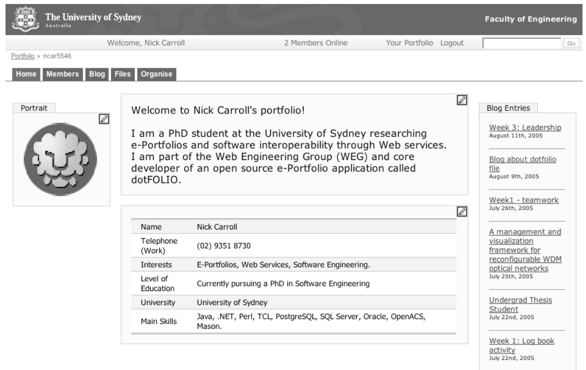

Fig. 1. Student's portfolio home page.

Teaching support tools for tutors provide functionalities for learning management. Dotfolio defines an administrator role for those managing the system, and allows them to create various groupings (e.g., class) and roles for different users (e.g., tutors, students). Tutors have direct access to a structured list of the students for whom they are responsible, with direct links to each student's portfolio, to aid efficient assessment. Teachers can write their feedback as a comment on student's entry.

All features are accessible from tabs at the top of the portfolio page (Fig. 1). They can be customized, added or removed by the course administrator. Due to the nature of open-source, the system can also be extended to cover new pedagogical scenarios and areas.

B. Architecture

The Dotfolio application was built using the OpenACS web application framework. This open-source framework provides components used to implement and integrate the features discussed above. The choice of the framework was based on the need for a development environment that facilitated maximum reusability of software design and implementation, particularly for e-learning applications. OpenACS is also used as a framework for the dotLRN Learning Management System, so institutions using Dotfolio can also automatically benefit from a complete open-source e-learning platform.

OpenACS has a multi-tiered architecture that uses AOLServer and the TCL programming language to implement the business logic, and PostgreSQL or Oracle for the persistence layer.

Institutions using postgreSQL have a 100% open-source solution. Among the numerous OpenACS installations worldwide, several of the largest support over 60,000 students.

The modular architecture, together with an extensive list of tool packages already available, enables developers to go from defining educational goals and software requirements to using a working prototype in a classroom in a very short time. The packages available include authentication systems like LDAP, implementation of interoperability standards like webDAV, XML-RPC and e-learning standards such as IMS-ENT, IMS-CP and IMS-LD. OpenACS applications can easily incorporate wiki pages, blogs, discussion forums, photo albums, e-commerce and other tools.

IV. Evaluation

A. Context

Dotfolio was trialed in a freshman year course called “Professional Engineering”. As a part of the course assessment, students were required to maintain a reflective logbook. The weekly logbook task required students to find current information in the media related to a specific discipline topic of the week (e.g., environmental sustainability, project management). Students were required to store a copy of this information and to write an entry in their personal logbook on the significance and importance of the issues discussed in the media to the engineering profession.

In previous years the logbook assignment was conducted as a paper-based task. Students were mainly restricted to text-based media and only the tutors could access and provide feedback. The use of Dotfolio expanded the possibilities of the assignment by allowing students to “clip” various sources of information to the logbook entry, including online newspaper articles, audio, video, technical reports and research papers. Students’ logbooks were placed in the public password protected web domain, so not only tutors, but other students could read the entries.

B. Instruments and procedure

A questionnaire-based survey method was employed to assess students’ beliefs, expectations and experiences about reflective learning and the use of e-portfolios. Data was collected twice: at the beginning of the semester, just after the introduction of Dotfolio tool and logbook assignment (week 2), and at the end of the semester, before the completion of the assignment (week 12).

The questionnaire administered in the first phase included students' general background information and attitudes (beliefs and expectations) about the reflective learning, task and logbook tool. The questionnaire administered in the second phase included only students' attitudes (beliefs and experiences).

Both questionnaires had two similar sections with multiple-choice and open-ended questions. The first survey included a multiple-choice question with 12 items worded in future or present tenses (see Table I). The second survey included the same 12 items, but worded in past or present tenses, plus two additional items assessing students' experiences only. A five-point Likert scale was used: 1 – "Strongly disagree"; 2 – "Disagree"; 3 – "Neutral"; 4 – "Agree" and 5 – ""Strongly agree". Both surveys included two open-ended questions that asked students to describe their (a) most positive feelings and (b) concerns about the logbook task and the Dotfolio tool.

The tutors provided their feedback about the task and Dotfolio during the teaching retrospective, after the course.

C. Subjects

Participants were the 260 freshman undergraduate students enrolled in the Professional Engineering course at the University of Sydney. The surveys were voluntary and 204 (78.5%) students completed the first survey, 145 (55.8%) completed the second one and 117 (45%) completed both. The responses from the latter group of respondents are analyzed in this paper. Feedback from tutors is used to assess the task and Dotfolio from the teacher's perspective.

D. Data analysis

The analysis of the data was divided into four stages:

1) Analysis of students' demographic information, past experience and present use of ICT for learning.
2) Analysis of students' attitudes toward reflective learning, the task and Dotfolio at the two points in time. To reduce complexity of the data, factor analysis using Principal Axis Factoring method was accomplished on 12 common items and composite mean scores for each factor were calculated. A paired sample t-test was employed for assessing significant changes in students' answers to individual items and composite factor scores.

3) Analysis of the open-ended responses about students' most positive feelings and concerns. Students' answers at the beginning and at the end of the semester were categorized, coded and compared.
4) Review of the teachers' feedback about the task and Dotfolio.

V. Results

A. Students' background and ICT use for learning

Of those who completed both surveys, 27 (23.1%) were female and 90 (76.9%) were male. The average age of the participants was between 18 and 19 years, M = 18.9, SD = 1.7, N = 117. The majority of students already had some learning experience with ICT. Specifically, 95 (81.2%) students had previously used an online learning management system (e.g. WebCT, Blackboard); 74 (63.2%) students had previously taken courses that had an online learning component (e.g. discussion forums, online assessment submission, access to online learning materials). Nearly all participants 113 (96.6%) had easy access to the Internet at the place in which they did most of their off-campus studies (e.g. home). On average they used a computer for various learning activities for 5.6 hours per week, SD = 6.5, N = 117.

B. Students' attitudes about the reflective learning, task and Dotfolio

The factor analysis identified three similar factors in students' answers at the beginning and at the end of the semester: F1 – "Reflective learning in engineering" (5 items); F2 – "E-portfolio tool" (2 items); F3 – "Collaboration with peers" (2 items) (Table I). The average factor scores were used in the analysis alongside individual item scores.

At the beginning of the semester, students disagreed most strongly with the two statements: (a) I would like logbooks to be included in other units of engineering studies (I10) and (b) The logbook task will improve my computer abilities (I7). The respondents were more positive about all other statements. On average, the students agreed most strongly with the statements about the importance of reflective learning in the engineering profession (F1), such as: (a) Reflective capabilities are important in the engineering profession (I11); (b) e-Portfolio or similar reflective learning tools can help engineers to keep up to date with current issues in their profession (I12); and (c) The logbook task will improve my capacities to reflect on various issues in the engineering profession (I6). The students were quite moderate about the functional features of the software (F2 and I3, I4) and even more negative about the benefits of collaboration with peers during this task (F3 and I8, I9).

There were several significant changes in students' opinions during the semester. Specifically, at the end of the course, the students were even more negative about the benefits of communication with peers during the task (F3). On average, they significantly increased their disagreement with the statements that classmates' feedback helped them to achieve the learning outcomes (I8); and that reading and commenting on their classmates' entries improved their own understanding (I9). In contrast, the students' experiences with the logbook tool were significantly more positive than were their initial expectations (F2). On average, the students had a significantly stronger agreement with the statement that the e-portfolio (online environment) was an appropriate tool for the logbook task (I3). In addition, at the end of the course, students were quite neutral, but inclined to agree that the logbook task was appropriately organized and facilitated by the teachers (I13) and that plagiarism is a concern with online learning tools (I14). There was no significant change in their attitudes about reflective learning in engineering (F1).

C. *Students' opinions about the task and tool*

In response to the open-ended questions, students wrote various positive comments and concerns about the logbook task and Dotfolio. In the first survey, 169 (83%) students wrote one or more positive comments and 143 (70%) indicated their concerns. Of those who responded, 52% students found Dotfolio easy to use and 30% liked the convenience of accessing their logbooks online. Some students (21%) were positive about the ability to communicate their ideas with peers. Nevertheless, a substantial minority of students were concerned about the complexity of Dotfolio (36%) and were anxious about possible technical faults (19%), potential plagiarism (18%) and a lack of privacy (15%).

At the end of the course, 94 (65%) students wrote their positive comments and 79 (55%) expressed concerns. Of those who wrote any positive comment, noticeably more students expressed their satisfaction with the logbook tool (55%). Almost a quarter of students also liked the convenience of online access to Dotfolio (23%). Very few students positively commented about the opportunities to communicate ideas with peers (14%) and/or enhance their professional knowledge (11%).

At the end of the semester, a smaller, but still quite large fraction of students expressed their

TABLE I

STUDENTS' ATTITUDES ABOUT THE REFLECTIVE LEARNING, TASK AND LOGBOOK TOOL AT THE BEGINNING AND AT THE END OF THE SEMESTER

Item / Factor		Survey 1		Survey 2		Difference				
	n	M	SD	M	SD	M	SD	t (sig)	Effect	Fact
I1. The main objectives of the logbook task are/were clear for me	112	3.55	1.00	3.53	1.02	0.03	1.21	0.234^{ns}	0.022	F1
I2. The logbook activity specification is/was easy to understand	112	3.37	1.00	3.42	1.00	-0.05	1.22	-0.464^{ns}	-0.044	—
I3. The e-Portfolio (online environment) is/was an appropriate tool for the logbook task	112	3.51	1.12	3.86	1.00	-0.35	1.11	-3.336***	-0.315	F2
I4. The e-Portfolio was easy to use	110	3.33	1.13	3.46	1.09	-0.14	1.17	-1.223^{ns}	-0.117	F2
I5. The logbook will enhance/enhanced my understanding of current professional engineering issues	112	3.28	0.96	3.34	0.98	-0.06	1.17	-0.564^{ns}	-0.053	F1
I6. The logbook task will improve/improved my capacities to reflect on various issues in the engineering profession	112	3.61	0.89	3.48	0.87	0.13	1.03	1.282^{ns}	0.121	F1
I7. The logbook task will improve/improved my computer abilities	110	2.91	1.23	2.84	1.25	0.07	1.24	0.615^{ns}	0.059	—
I8. My classmates' feedback on my entries in the logbook will help/helped me to achieve the learning outcomes of the Professional Engineering unit	111	3.06	0.97	2.56	1.04	0.51	1.23	4.33***	0.411	F3
I9. Reading and commenting on my classmates' entries in their logbooks will improve/improved my understanding of current professional engineering issues	112	3.20	1.05	2.78	1.07	0.42	1.29	3.456***	0.327	F3
I10. I would like logbooks to be included in other units of engineering studies	111	2.40	1.19	2.63	1.18	-0.23	1.35	-1.831^{ns}	-0.174	—
I11. Reflective capabilities are important in the engineering profession	112	3.68	0.88	3.77	0.86	-0.09	0.99	-0.953^{ns}	-0.090	F1
I12. e-Portfolios can help engineers to keep up to date with current issues in their profession	111	3.56	1.01	3.65	0.87	-0.09	1.28	-0.744^{ns}	-0.070	F1
I13. The logbook task was appropriately organized and facilitated by the teachers	111	—	—	3.35	0.99	—	—	—	—	—
I14. Plagiarism is a concern with online learning tools	112	—	—	3.48	1.11	—	—	—	—	—
F1: Reflective learning in engineering	111	3.53	0.71	3.55	0.66	-0.02	0.79	-0.240^{ns}	-0.264	—
F2: E-Portfolio tool	110	3.41	0.99	3.67	0.94	-0.26	0.97	-2.755**	-0.023	—
F3: Collaboration with peers	111	3.12	0.92	2.68	0.97	0.45	1.11	4.261***	0.404	—

Notes: *n* – Number of respondents; *M* – Mean; *SD* – Standard Deviation; *Effect* – Effect Size; *Fact* – Factor to which the item belongs (based on Principal Axis Factoring method, oblimin solution, item loads 0.5 or above in Survey 1 and 2); *sig* – significance level; *** – $p < 0.001$; ** – $p < 0.01$; * – $p < 0.05$; *ns* – Not Significant.

concerns about the complexity of Dotfolio (29%) but very few students were concerned about actual or potential technical faults of the system (8%). However about quarter of students (25%) were concerned about plagiarism. No student explicitly stated that they experienced problems with plagiarism, but that they were concerned about the potential danger of what “might occur”.

D. Teachers’ opinions about the task and tool

The teachers commented that the workload was not much of a burden (there were 10 tutors marking portfolios). They could do this work either at home or at the university and did not need to carry around printed assignments. Tutors liked the possibility to read online articles and other resources that students selected for their reflection, including videos, podcasts, YouTube. The primary concern for teachers was related to plagiarism, as several cases of such academic misconduct were detected.

VI. Discussion and Conclusions

A. Discussion

The results indicated that students understood the importance of and valued reflective thinking skills in engineering. Nevertheless, students disliked the logbook task, particularly in the beginning. Some comments indicated that this activity was very different from their typical learning experiences and students wanted a more specific, structured task.

Overall, students primarily focussed on their individual learning opportunities. The majority of students’ positive comments were related to the facts that Dotfolio is a based-web application, has an easy to use repository and browser-based writing environment. Students found the following Dotfolio functionalities most useful: access anytime and at anyplace with an Internet connection; possibility to use Internet content for reflection; no need for special software to complete the task; the simplicity of the interface and easy linking of the media resources to their own reflective thoughts. Most of these features were enabled by the modular architecture of the OpenACS framework. Initially some students found Dotfolio complicated and did not trust the technical robustness of the new learning platform, but this was less an issue at the end of the course, once they had used it.

Students commented less about the collaborative learning opportunities and functionalities. A significant number of students little valued or disliked the overall idea of collaboration in this task. Most of them did not see the benefits of collaboration for learning, preferred privacy and were anxious about the potential danger of plagiarism. None of them negatively commented about specific technical features of Dotfolio for collaboration and social networking. Therefore, students' negative perceptions about the collaboration were likely to be caused by the tension between the privacy of reflection and the sharing of ideas (reinforced by the potential risk of plagiarism).

Dotfolio provided sufficient teaching support. Teachers' positive opinions were related to the flexibility, convenience and other features that were enabled by the web-based application framework. Teachers' concerns were related to the students' misuses of collaborative learning functionalities (i.e., plagiarism).

This result indicated the primary need to enhance students' awareness about the importance of collaboration and provide students and teachers with a safer environment. Therefore, a new component for the detection of plagiarism has been added to Dotfolio. The open-source architecture allowed the developers to implement this amendment within several months. Additional changes that promote student collaboration, need be implemented within the design of the learning activity.

B. Conclusions

There is an increasing awareness of the need to educate ”reflective practitioners” and to develop individual and collaborative reflective thinking and learning capabilities in engineering subjects. This paper introduced a new open-source portfolio system that supports lifelong learning and reflective thinking, and described an evaluation of students' and teachers' perceptions about the learning task and the tool.

The freedom to modify the tool is an important attribute of open-source systems. In this project, the open-source modular architecture allowed the system to be extended with components that support individual and collaborative reflection, and meet changing pedagogical requirements after the initial trial of Dodfolio. The numerous packages available in the OpenACS framework can be integrated and modified offering opportunities for innovative pedagogical designs. As an example, a new report writing tool has been added to Dorfolio and is currently in use in a psychology course. Students and teachers particularly appreciated the benefits of a fully web-based framework that allowed them to enjoy flexible access and easy integration of media resources into their logbooks.

The design of e-learning and the development of open-source educational software is an interrelated and iterative process. In order to make relevant changes in the functionalities, comprehensive evaluations are needed. This paper demonstrated how the development of open-source e-learning products can benefit from a broader robust evaluation that assesses functional features and interprets results in the broader context of learning aims (pedagogical approach and task). Only an open-source modular architecture could have allowed the results from the evaluation to be fed back into the design immediately.

Open-source systems, like Dotfolio, are in a unique position to be developed gradually and effectively, and to be improved by the academic communities that use them. As more broad research studies are conducted, software improvements can be made in an increasingly informed way, based on empirical evidence about the success of learning strategies and students' experiences.

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