

A review of the development of electronic portfolios in education and health care disciplines: supporting students' learning and continuing professional development

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Abstract Using a portfolio approach is not a new idea in health care disciplines as an alternative assessment format and for Continuing Professional Development (CPD). Increasingly, the use of electronic portfolios is noted in the literature. This paper critically reviews developments, features, advantages and problems relating to different modes of operation. The review is conducted with educational and CPD usage in mind particularly for the health care professions where reflective practice, applied learning and outcomes-based education are prominent pedagogies. The most appropriate types of electronic portfolio practice are also discussed. Although a number of problems were noted with earlier types of electronic portfolio, they have been rectified by the current existing modes of operation. It is suggested that the development of reflective abilities and professional development are well served with the currently available technology incorporating capabilities of collaborative learning, storage and management, portability and access, flexibility and multi-media contents. Although web and web database portfolios tend to be role models for electronic portfolios, the most appropriate type depends on the values of the stakeholders. This paper concludes that web portfolios provide greater flexibility in building and are feasible in small size situations such as subject-based portfolio practice or personal use for CPD records. Web database portfolios should be the only choice at institution or professional society level because of the capability to serve a large population. Reflective learning and professional development can be captured using electronic portfolio systems, and further advances on the current technology will evolve. What is important in establishing an electronic portfolio is to ensure that the content requirements remain the most important aspect and that development is seen to support this aspect rather than focusing on the technical process of portfolio building.

Keywords: CPD, e-portfolio, electronic portfolio, pedagogy, portfolio, reflection

Introduction

Using a portfolio approach is not a new idea in health care disciplines as an alternative assessment format and for continuing professional development (CPD). Increasingly, the use of electronic portfolios is noted in the literature. One example is *CPD Now* developed by The Society and College of Radiographers.¹ The electronic portfolio is one means of addressing the intrinsic problem of paper portfolios, such as resource demand issues. Hence, e-portfolio usage in higher education has boomed with enthusiasm and big claims.² However, without a complete understanding of electronic portfolios, their value may diminish and they may simply become another form of resume or documentary.³

Early use of electronic portfolios can be traced back at least twenty-five years.³ Although technology could not provide adequate functionality to enhance the users' experiences at that time, it did provide a fair environment for builders to create a sound portfolio.⁴ However, criticisms of the use of electronic portfolios have emerged recently.^{2,3} Is this a problem with the latest technologies or is it a backwash effect of the portfolio implementation settings? This article provides a review of electronic portfolio practice in terms of its development, features, advantages and problems

relating to different modes of operation. Previous literature on electronic portfolios is critically reviewed to illustrate these issues. The review is conducted with educational and CPD usage in mind, particularly for the health care professions where reflective practice, applied learning and outcomes-based education are prominent pedagogies. The most appropriate types of electronic portfolio practice are discussed with the aim of supporting relevant stakeholders, including educational institutions, professional societies, and registering bodies for health care disciplines, to make the right choice from existing modes of electronic practice.

Methods

A comprehensive literature search was conducted using the ScienceDirect and Ovid databases, using the keywords electronic portfolio and e-portfolio to identify relevant articles. Only articles relating to health care or education disciplines were then selected for the review.

Discussion

The main body of this discussion focuses on the different electronic portfolio systems and developments that have occurred due to different demands that have arisen, or the problems noted

with existing formats. It is kept in mind that within health care, for either education programs or CPD purposes, both academic and professional development should be noted, the connections students or practitioners may see between the two, and their ability to adapt and adjust learning informed by experience and practice. Portfolios can be seen as an instrument which can support both the outcomes-based educational approach and notions of meeting competence in current health care education and professional accreditation processes. The purpose of both usually aim at fostering reflection on previous learning and practice experiences, and leading to applied learning and continuous development in a cyclic manner.⁵⁻⁸ Electronic portfolios further create opportunities, for example, to provide this ongoing support and facilitation from pre-registration education to later CPD activities and link them as a whole for illustration of development to different parties such as academic institutions, registering bodies and employers based on the enormous capability of storage and management.^{3,9-11}

Development of electronic portfolios

Electronic portfolios in education have increased in use over the past 25 years.³ In the 1980s, the electronic portfolio was simply used as a file folder for archiving evidence of progress and development, and reflections, in the computer hard drive. Portability was limited by the use of floppy disks or optical disks to accommodate multimedia file formats such as images and video.⁴ In the early 1990s, educators voiced dissatisfaction with the portability constraints of previous modes of operation, which made it difficult to develop collaborative learning. Hence, network file folder systems were used to facilitate collaborative learning among students through file-sharing capabilities, i.e. sharing portfolios.¹² This kind of practice remained prominent up to the mid 1990s.¹³⁻¹⁵ However, educators gradually identified the shortcomings of this mode of electronic portfolio, as it was difficult to establish linkage between different artefacts to allow the portfolio to be considered or revised holistically. Subsequently, a new mode of electronic portfolio emerged via a bulletin board system (BBS) which could further facilitate collaborative learning due to a better dialogue process among peers and tight, more coherent, individual artefacts.^{12,16} In the mid 1990s, commercial software packages for electronic portfolios emerged. Apart from the networking capabilities, which allowed collaborative learning, these packages supported users in creating hyperlinks between artefacts, i.e. a hierarchy structure to strengthen the coherence of portfolios. However, this practice was not very successful. In order to build the electronic portfolio in this way, users needed to obtain the packages and install them on computers. In this case, it was difficult to have collaborative learning unless students exported their individual portfolios onto CD-ROM and brought them back to a computer laboratory, or the computer consoles for portfolio building were in a networked environment. It also took time to learn to use the software.^{17,18}

From 1995 onwards, development of the internet came to the stage of commercialisation whereby government agencies expected corporations to take up the initiative to maintain and expand the internet backbone and services worldwide. One of the most popular features of the internet is the world wide web which allows access to a huge number of homepages composed in hypertext markup language (HTML).¹⁹ Therefore, educators applied this technology to the electronic portfolio which became the web portfolio.^{3,20,21} It seems that the web portfolio is the most successful type of electronic portfolio as it remains the

mainstream not only in the education field but also in the health care disciplines.^{1,3,10,22} Nevertheless, the latest type of electronic portfolio is not a web portfolio but a database portfolio system,^{3,11} of which there are two. One is an offline mode,⁹ and the other is web based.^{3,11} The web based type is more advanced than the offline mode, at least in terms of technology and functionality, since web database portfolios have capabilities that inherit all the strengths of previous modes of electronic portfolio plus their own privileges as a database. Offline types, however, can only provide the strengths of databases such as hyperlinks between artefacts, and an easy record storage and management system.^{3,9,11} In order to avoid confusing terminology, 'offline database portfolios' will be used to refer to the offline type and 'web database portfolio' for the web based mode.

Features of electronic portfolios – hypertext

Purves¹⁸ suggests that the nature of portfolios should be electronic hypertexts. There are many existing examples of hypertexts in the electronic world, such as electronic encyclopaedias and the internet.¹⁷ The characteristics of hypertext mean that the author of a portfolio organises and arranges artefacts into a network or hierarchical structure to be presented to readers in a coherent manner. However, readers are granted some degree of flexibility or freedom to re-arrange the connections between artefacts and hence look at the portfolio in different ways.^{17,18,21,23} With the earlier modes of operation of electronic portfolios, such as using a file folder in the hard drive or the network file folder system, hierarchical structures could be easily established between folders and sub-folders.^{12,14}

With the establishment of the BBS mode, a more coherent linkage evolved with networking between artefacts.^{12,16} Commercial software packages for electronic portfolios are hypertext tools which offer a number of facilities for users to create hyperlinks between artefacts.¹⁷ The characteristics of hypertext, i.e. HTML, are the core components of the more recent technologies, such as web and database portfolios and all types of electronic portfolios today should have the hypertext feature.^{3,11,21,23}

Comparisons between different types of electronic portfolio advantages

Collaborative learning

Initially, the emergence of electronic portfolios was not primarily to solve resource problems, i.e. time-demanding, or storage and management issues, as was the case with the paper portfolio.²⁴ The major use was to facilitate collaborative learning involving the sharing of portfolios with peers, and providing comments and feedback on others' portfolios. Although all forms of electronic portfolio can fulfill this requirement, some types are more advanced than others.^{14,15,25,26} The offline types, including the disk format, portfolio software approach and database portfolio, can offer limited functions of collaborative learning through the use of different portable media such as CD-ROMs to provide duplicate copies for peers.^{4,11,15,18,23} Using the networked environment, collaborative learning is much easier through sharing of files. The types of electronic portfolio which work in the networked environment include the network file folder, BBS, portfolio software approach, and the web and web database portfolios.^{3,10,13,16,17} However, the first three types usually work in the ethernet (local area network) environment and hence the degree of reach is still limited.^{12,14,17,18} Since both web and web database portfolios are built on the internet, they inherit its strengths, such as ubiquity, global reach,

universal standards, richness, interactivity, information density and personalisation. They are strong in facilitating collaborative learning.^{3,11,19,25}

Storage and management

The electronic portfolio may be used to archive a large amount of students' or practitioners' submitted evidence over a long period of time, and is supported by the inherent computing functions such as sorting, searching and duplicating.^{3,9,11} Huot²⁶ suggests that the digital revolution enables the possibility of having alternative assessments to serve a large population, which was difficult in the past. Although it may be costly to set up the entire system, it is still relatively inexpensive for this purpose.¹¹

Storage capacity does not differ much between various types of electronic portfolio as this depends on the kind of storage media. Existing types of media are compatible with different modes of portfolio operation.^{11,15,17,18,23} However, management differences do exist. For storage management, the disk and network file folder formats rely heavily on the storage functions embedded in the operating system (OS).^{4,12-14} Both BBS and portfolio software approaches provide a more user-friendly interface for users to store their portfolio in a more organised manner because of built-in functionalities, such as the hypertext capability to coherently link fragmented data.^{12,16-18} Web portfolios inherit all the capabilities of the internet, such as hypertext, and hence have a more advanced mode of storage management compared with the BSS and software approaches.¹⁹ However, both offline and web based database portfolios employ the database technology developed for ease of retrieval, insertion, updating and deletion of data; and therefore offer the best experience for handling large amounts of data over a long period of time. Indeed, the effectiveness and efficiency of data retrieval depends on the method of storage. Databases can offer a powerful capability for data management, since all the data to be stored can be organised into a table. Through the use of special algorithms, archived data can be retrieved efficiently and organised into a meaningful report.²⁷ Therefore, database portfolios are the strongest with regard to storage and management, web portfolios second, and BBS and portfolio software approaches third. The disk and network file folder formats are the least effective.

Portability and access

The ranking of portability and access capabilities is more or less the same as the ease of facilitation of collaborative learning, since the file sharing component of collaborative learning lies in these capabilities. Therefore, web and web database portfolios are best for portability and access purposes.^{3,11,19,25} Approaches using the ethernet environment, including the network file folder system, BBS and portfolio software approach, come second^{12,14,17,18} while the offline types, such as disk format, portfolio software approach and database portfolio, are the least effective.^{4,11,15,18,23}

Interactivity (dynamics) and flexibility

Interactivity (dynamics) is a feature of electronic learning, in contrast to the traditional static learning approach, and all electronic portfolios inherit this characteristic to some degree.^{13,17,18,22} For the electronic portfolio, interactivity often refers to the readers' ability to take control of changing the output (mode of display) instantly without altering any organised materials archived.³ Therefore, it is a similar concept to hypertext.^{13,18} In order to offer readers the choice to view the portfolio from another angle, it is necessary for authors of portfolios to organise and arrange artefacts into a network or hierarchical structure to be presented in a

coherent manner, i.e. setting up hierarchical structures or hyperlinks. Therefore, the ranking of interactivity should be more or less the same as that of the hypertext capability. Disk formats and network file folder systems are the least effective.^{12,14} BBS is better than earlier modes,^{12,16} while commercial software packages lie between the BBS mode and web and database portfolios, which appear to be the best.^{3,17,21,23}

With the revolution of web database portfolio systems, the degree of interactivity is extended.¹³ Purves¹⁸ suggested that the interactivity of electronic portfolios should be based on hypertext. In the web database portfolio system, contents of a web page are archived as objects in the database instead of as pre-written solid codes in HTML. When the readers of portfolios access a particular page, the contents are retrieved from the database rendering into an organised manner based on the server-side scripts known as dynamic page generation.¹⁹ These programs take into account the readers' conditions, such as cookies, and input, such as user name, password, queries, etc. to determine the ways and contents for rendering. Therefore, interactivity of web database electronic portfolios is not solely based on pre-written hyperlinks but also the dynamic page generation technology. Batson² suggested there is a distinction between the web database portfolio system and other modes of electronic portfolio. The former can be classified as a dynamic portfolio while the latter is a static portfolio. However, this is not a flawless classification. For example, the dynamic HTML (DHTML) which is powered by client-side script, such as JavaScript, can provide some extra interactivity other than hyperlinks, but does not involve any database integration.^{3,27} Also, it is feasible to employ the dynamic page generation technology without the use of a database.²⁷ For example, Pullman¹¹ used CGI to establish an electronic portfolio system, 'efolios' which can provide functions similar to the web database portfolio without any involvement of a database.

Although it would seem that the term interactivity would have some association with flexibility, they are opposite to one another from the perspective of electronic portfolio development. For the web database portfolio, interactive contents would be preferable. However, these contents are not created or designed by the authors of the portfolio but rather by the server-side scripts which are compiled by programmers. The author's role shifts from creator to content provider or uploader. The flexibility of portfolio building is limited due to the constraints imposed by the server-side programs. The rule of thumb in terms of flexibility is that systems like electronic portfolios offer less flexibility and more standardisation for the authors.³ It seems that the ranking of flexibility is the reverse of interactivity. However, apart from database portfolio systems, the flexibility of other types would be similar because little intrinsic standardisation is imposed.

Multi-media contents

Since the emergence of electronic portfolios, multi-media contents as artefacts have become part of the bundled capability.⁴ The multi-media artefacts that cannot be inserted into the paper portfolio, such as audio and video, can be easily incorporated into the electronic portfolio and therefore extends their scope.^{10,14,15,18}

Problems

Pullman¹¹ commented that all technology innovation aims to solve current problems but in turn generates other problems. Along with the development of different types of electronic portfolio, problems or shortcomings encountered in the earlier modes of operation have been resolved. However, for the existing types of electronic portfolio,

some weaknesses remain unaddressed. It is, therefore, worthwhile looking at the problems of electronic portfolios at different stages as a blueprint to overcome those that remain unsolved.

Portability access and equity

The portability and access of electronic portfolios has improved with time. Through the introduction of internet technology, web and web database portfolios provide promising solutions to the previous modes, i.e. ubiquity, global reach and universal standards. The ubiquitously global reach feature brought by the internet has addressed the weaknesses of portability and access of both offline and ethernet types, including disk format, network file folder system, BBS, portfolio software approaches and database portfolios.^{3,11,19,25} Also, these characteristics have solved various problems related to equity. Inequity usually arises because of the physical unreachability of the portfolio building facilities, such as difficulty in accessing the facilities of portfolio building in the offline and ethernet types, usually situated in the computer laboratories, and attaining the software package and OS compatibility for the portfolio software approach.^{4,12,15,18} However, web and web database portfolios, through the use of browsers, such as Netscape (developed by Netscape Communications Corporation) which is free of charge and cross-platform, can be viewed and edited (through the use of bundled components, Netscape's Composer) at any time and place.¹¹

Cost of implementation and maintenance

It might be considered relatively expensive to implement and maintain the disk and software formats for electronic portfolios, as they could require the hiring of technicians and purchase of hardware and software.^{4,11,17,18} However, during the past decade, the cost of hardware has become much cheaper and more affordable. Apart from the portfolio software approach and web database portfolio system, there should be no need to have any software other than the bundled OS. Since the portfolio software is a commercial product, it aims at money return, and may cost from \$A 110 to \$A 2270. For web database portfolios, as the serving population extends far beyond the previous modes of electronic portfolio, it is necessary to have more powerful computer systems/servers and database software. Also, it is necessary to have technicians to set up the web database portfolio system or purchase the whole commercial system. This is still relatively inexpensive for institute-wide situations.^{3,11}

Portfolio building

Although portfolio software approaches and web portfolios belong to more advanced modes of electronic portfolio practice, a serious problem has been encountered: the need to teach authors how to build portfolios electronically. It may be difficult for teachers to concentrate on teaching compulsory components because extra effort would need to be devoted to teaching students how to use the software in the portfolio software approach, while compiling HTML codes for the pages in the web portfolio situation.^{3,11,17,22} There is a danger that the emphasis can be placed on teaching the use and procedures of managing a portfolio, rather than the development of relevant content and how the user can demonstrate development and reflective comment. As noted above, web database portfolio systems try to limit the flexibility and standardise all the portfolio building procedures and hence this is a solution to the problem. It creates the possibility of serving a wide population.³

Security, privacy, ownership and persistence

Along with the increase in portability and accessibility in the

development of electronic portfolios, issues of security, privacy, ownership and persistence become prominent concerns. In the offline and ethernet modes of electronic portfolio, portability and accessibility are limited and they are usually located in a secure environment such as a computer laboratory. The threat of security problems can be easily eliminated by locking the system up physically.⁴ However, for portfolios situated in the internet environment, ubiquity, global reach and universal standards create the pitfall of security vulnerability, as ease to view and edit portfolios facilitates possible attack from different forms such as hacking and virus in the cyber environment. Therefore, both physical and electronic security measures should be in place. It is noted that there is always a tension between security and other values, such as ease of use of the system.¹⁹ It is suggested that anti-virus software and password authentication would, however, provide adequate protection to the system.^{11,25}

Good security practice ensures the basic protection of privacy of submitted data archived in the system. However, protection of privacy also depends on what data privacy regulations are enforced in the institutions. If there are no proper regulations, other problems such as surveillance may arise, especially in the case of enterprise-level database portfolio systems, due to the intrinsic power of effective and efficient data management.³ Another related privacy concern is the ownership issue. There is no definite conclusion over the ownership of electronic portfolios, so it is difficult to establish practical regulations to protect data privacy effectively.^{3,18} Although the persistence of portfolios as a result of the enormous storage capability of web database portfolios is a new concern, if there are no proper measures in place, it will leverage the effect of the first three issues, since the chance of threats to security, privacy and ownership would increase over a period of time.³

Miscellaneous problems that have been solved

Purves¹⁸ reported that many commercial portfolio software packages did not have the necessary tools to facilitate feedback and commentary by teachers or reviewers. However, currently systems like web and web database portfolios provide different channels such as message boards for teachers to conveniently achieve this aspect.^{3,25}

It is clear that electronic portfolios have moved well beyond the benefits brought by paper portfolios and address the ultimate weakness of the latter, i.e. resource demands. Although in the earlier types of electronic portfolio a number of problems were noted, they have been rectified by the current existing modes of operation, especially the web database portfolio. Table 1 summarises the strengths and weaknesses of different types of electronic portfolio. It is suggested that the development of reflective abilities and professional development would be the best served with high ratings in collaborative learning, storage and management, portability and access, flexibility and multi-media contents. Flexible environments foster students and practitioners to exert reflective abilities to organise materials in a meaningful sense with the support of the storage and management functionality and multi-media contents such as medical images and over the period of professional life.^{3,10,21} Collaborative learning, and portability and access further polish their developments based on the feedback and comment from others.^{14,15,25,26}

The most appropriate types of electronic portfolio in practice

As noted in Table 1, web and web database portfolios tend to be role models for electronic portfolios. However, several

Table 1 Strengths and weaknesses of electronic portfolios

Type ^A /feature ^B	Disk Format	Network File Folder System	BBS	Portfolio Software Approach	Web Portfolio	Database Portfolio	Web Database Portfolio
Collaborative Learning	7	3	3	3 (Ethernet)/ 7 (Offline)	1	7	1
Storage & Management	7	7	4	4	3	1	1
Portability & Access	7	3	3	3 (Ethernet)/ 7 (Offline)	1	7	1
Interactivity (Dynamics)	7	7	5	4	1	1	1
Flexibility	1	1	1	1	1	7	7
Multi-media Contents	1	1	1	1	1	1	1
Portability, Access & Equity	7	7	7	7	1	7	1
Cost of Implementation & Maintenance	1	1	1	5	1	5	7
Portfolio Building	3	3	3	6	7	1	1
Security, Privacy, Ownership & Persistence	1	1	1	1	7	1	7

^A Unformatted – Offline Type; *Italic Style* – Ethernet Mode; Underlined – Hybrid (Either Offline or Ethernet); **Bold Style** – Internet Mode

^B 7-point Scale Rating for Features: 1 (Strongest) – 7 (Weakest)

problems are still noted for each type. Web database portfolios reinforce the storage and management capability and address the problem of time commitment for teaching students how to compile HTML codes for the web portfolio, but generate problems of cost of implementation and maintenance, which although justified may be lacking flexibility. In other words, apart from security, privacy, ownership and persistence, the characteristics of storage and management, flexibility, cost of implementation and maintenance, and portfolio building of web and web database portfolios complement one another.

In practice, the most appropriate type of electronic portfolio depends on the values of the stakeholders. Web database portfolios are frequently under criticism for over standardisation, i.e. over simplification of portfolio building procedures. This may lead to losing reflection capabilities inside portfolios, which is the crucial element of portfolio pedagogy. However, web portfolios require authors to start from scratch with their masterpieces which fosters reflective thinking throughout the essential steps of portfolio building including 'collect', 'select' and 'reflect' of evidence of development.^{3,10,21} Although it is argued that web portfolio processes may turn portfolio builders to personal homepage designers due to the flexibility, stakeholders can have full control of this happening through training in portfolio building.^{3,11} However, web database portfolios are usually in the form of commercial systems. Buyers then have little control to alter the over standardisation situation.³

If the stakeholders want to formalise the portfolio practice into institutions or societies, web database portfolios are the way to go. It can provide on a large scale learning opportunities, assessment possibilities and tracking capability of development for pre-registration education and CPD.^{2,3} Although standardisation is the trade-off, its impact can be minimised or justified. The most direct

approach is to select a commercial web database portfolio which has a strong basis of portfolio pedagogy and provides functions to align it. However, the ultimate solution would be to tailor a system which offers greater flexibility to students or practitioners as composers, with some standardisation to ensure efficiency. Together with training in both reflection and portfolio building, the situation can be greatly improved.³ This also aligns with common portfolio practice to assess competence in the health care disciplines, and is the standards based portfolio, i.e. a collection of an individual's work to address development of a list of pre-determined competences.²⁸

Conclusion

Electronic portfolios have emerged over the past 25 years in the education and health care disciplines evolving from the earlier mode of disk format to the latest technology of web database portfolio. This practice provides an intrinsic hypertext environment aligning with the nature of portfolios, including the need to provide reflective input and the ability to demonstrate progressive development. Advantages of electronic portfolios over the original paper portfolios are, for example, further facilitating collaborative learning, advancement in storage and management, high portability, ease of access, interactivity, more flexibility and multi-media compatibility. Although enterprise-level database portfolio systems are the most advanced type of electronic portfolios, web portfolios are still the mainstream. The most appropriate choice depends on the values of the stakeholders. Web portfolios provide much flexibility in building and are feasible in a small situation such as subject-based portfolio practice or personal use for CPD records. Web database portfolios should be the only choice at institution or professional society level because of the capability to serve a large population. As yet, a flawless web database portfolio has not been established. The ultimate solution would be to

develop a system which can maintain a balance between flexibility and standardisation, and provide to authors adequate training on reflection development and portfolio building. This thoughtful way of development of the enterprise-level database portfolio system would be the right way forward. There is no doubt that an emphasis on reflective learning and professional development can be captured using electronic portfolio systems, and further advances on the current technology will evolve. What is important is that the content requirements remain the most important aspect and that development is seen to support this aspect rather than the technical process of portfolio building.

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