Analyzing Research on Teachers' Electronic Portfolios: What Does It Tell Us about Portfolios and Methods for Studying Them?

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Abstract

This survey paper uses a framework derived from Herman and Winters (1994) to analyze seven selected research studies for evidence of electronic portfolios' technical quality, implementation effects, fairness, feasibility, and tool effects. Analysis sought to determine what methodologies and instruments for data collection yielded useful information about electronic portfolios, and what the findings and methods suggest about directions for future e-portfolio research. The author's recommendations are placed in the context of an educational technology research agenda proposed by leaders in the field.

Portfolios have become a widely-used method of assessment in American education—particularly for teachers. Nearly 90% of schools, colleges, and departments of education (SCDEs) use portfolios to make decisions about candidates (Salzman, Denner, & Harris, 2002). School districts are using portfolios in mentoring programs for novice P–12 teachers (MacIsaac, 1992; Whitaker & Ray, 1994) and for professional development of more experienced teachers (Wolf, Lichtenstein, Bartlett, & Hartman, 1996). States and national professional organizations have begun experimenting with portfolios as ways to assess and certify exemplary teachers (Dollase, 1996; Izu, Long, Stansbury, & Tierney, 1995; National Board, 1989). Portfolio assessment of student learning is also common in P–12 schools (Dollase, 1996).

A Dearth of Empirical Research

Portfolio proponents cite strong theoretical support for their use by both teachers and students, arguing they are good devices for capturing evidence of knowledge in context and prompting new learning (e.g., Shulman, 1987, 1992, 1998; Wiggins, 1989; Yancy, 1992). Unfortunately, empirical evidence documenting the effects of portfolios is sparse. In 1994, Herman and Winters noted the supposed advantages of portfolios for learning and assessment, but pointed out deficiencies in the research: "Of 89 entries on portfolio assessment topics found in the research literature over the past 10 years, only seven articles either report technical data or employ accepted research methods. Relatively absent is attention to technical quality, to serious indicators of impact, or to rigorous testing of assumptions" (p. 1).

Has the research situation improved since 1994? Not greatly, it appears. Lyons noted in 1998: "There is not yet a body of systematic data documenting their [portfolio] uses or their long-term consequences" (p. 247). More recently, Zeichner and Wray (2001) voiced the same concern: "Despite the current popularity of teaching portfolios, there have been very few systematic studies of the nature and consequences of their use for either assessment or development purposes" (p. 615).

Are portfolios effective devices for assessing and developing knowledge, as proponents claim? We have little empirical evidence to make the case.

Expanding Use of Electronic Portfolios

As the portfolio becomes an ever more prominent device for assessment and learning, advances in technology are radically changing its form. Once predominantly paper text, portfolios are now more likely to be digital products presented using the computer—either by means of off-the-shelf tools or server-based software. In higher education, teachers and students are increasingly being given access to electronic portfolio systems on institution servers. According to the 2004 Campus Computing Project survey (Green, 2004), electronic portfolios are currently provided by nearly 30% of public universities and 18% of private universities across the country.

The use of electronic portfolios has become even more common in teacher education. Colleges of education, under pressure by state and other accrediting agencies to document students' standards-based competencies, have embraced the technology. One sign of their interest is that 50% of the 400 Preparing Tomorrow's Teachers to Use Technology (PT[3]) programs have used grant funds in part to develop and implement electronic portfolio systems (Britten, Mullen, & Stuve, 2003).

How do these emerging digital technologies affect portfolio product and process? Although we have a host of preliminary reports about implementation in teacher education programs, there have been very few systematic studies to probe assumptions about the device and provide empirical evidence of electronic portfolios' effectiveness for assessment or learning.

Concerns and Questions about Electronic Portfolios

Despite their increasing popularity, a host of questions and concerns have been raised about electronic portfolios. Maddux and Cummings (2004) have suggested that electronic portfolios might be one of the current hot topics susceptible to being caught up in what they refer to as the pendulum syndrome. This term refers to the tendency for many a new educational practice or technology to be greeted with overly optimistic claims; then when the innovation fails to live up to unrealistic expectations, it is abandoned—often before it has even been fully or appropriately implemented. Efforts to validate the innovation through research are often still at preliminary stages when its wave of popularity ends and the practice is discarded. We might ask ourselves: In the absence of research to guide their use, will electronic portfolios be an educational fad destined to go the way of Papert's Logo turtles?

Developments in software also prompt new questions and concerns. Although most electronic portfolios were initially constructed with

off-the-shelf productivity or Web authoring software, their nature is now being transformed by specialized e-portfolio software. In teacher education especially, many electronic portfolios are now constructed with commercial database software residing on an institution's server (e.g., LiveText, Chalk and Wire, Taskstream). These portfolios are often highly structured and used for large-scale assessment and program evaluation. Barrett (2004) argues that in many cases, these products should more properly be called assessment management systems rather than electronic portfolios. What are the implications of using portfolios for such high-stakes assessment?

If portfolios are going to be used to make important screening and placement decisions about teachers or students, we need to be very careful that they meet the technical standards for any good measurement device. Do we have empirical evidence that portfolios can be scored reliably and that they enable us to make valid interpretations of a candidate's competencies? And even if portfolios can be made to function in this way, is it wise to use them in such a manner? If we use portfolios to make high-stakes decisions, will we have destroyed their usefulness as a learning tool—making them what Shulman (1998) has referred to as a "very, very cumbersome multiple-choice test" (p. 35).

These are but a few of the questions that have been raised about electronic portfolios—and few answers are to be gleaned from published research.

Limited Research on Electronic Portfolios

In examining portfolio literature one soon notes that most articles and papers on the subject are conceptual or anecdotal rather than research-based. Many are implementation reports describing the features of particular portfolio programs, frequently accompanied by survey or interview data on the attitudes and beliefs of portfolios authors. Although description of the manner in which portfolios are implemented can be useful in the design of other portfolio systems and can identify promising areas for research, this type of inquiry in and of itself will not make the case for portfolios as effective assessment or learning devices.

Many studies offer self-report data from authors who testify to the learning benefits of the portfolio; researchers must be careful not to stop there. Additional data are needed to establish the veracity of portfolio authors' perceptions. If the purpose of a portfolio is to foster learning, hard evidence that the portfolio has indeed advanced the author's knowledge must be sought. If the primary purpose of a portfolio is assessment, we need confirmation that an evaluator is able to use portfolio evidence to accurately assess a candidate's skills and knowledge—whether that argument is based upon principles of psychometrics or hermeneutics (Moss, 1998).

National Electronic Portfolio Research Initiatives

The many questions about electronic portfolios and scarcity of research have prompted new national efforts to study them. One noteworthy example is the National Coalition on Electronic Portfolio Learning, coordinated by the American Association of Higher Education and Clemson University's Pearce Center. This three-year project enlists the efforts of faculty from 30 higher education institutions to design research on digital portfolios' effects on learning.

The use of Web-based electronic portfolios among high school students is the focus of the Researching Electronic Portfolios: Learning, Engagement, Collaboration through Technology (REFLECT) initiative, led by Helen Barrett and underwritten by TaskStream. This 18-month national action-research project will study the effect of electronic portfolios on high school students' learning, motivation, and engagement.

Large-scale research is also underway to understand the diffusion of e-portfolios in schools, colleges, and departments of education (Strudler & Wetzel, 2005). Beginning with a survey completed by 23 institutions thought to be mature users of the technology, Strudler and Wetzel chose six institutions from across the country for in-depth study. Data collection includes site visits and more than 80 interviews.

In addition to these national efforts, many individuals and groups plan their own research on electronic portfolios. What direction should this research take, and what methods would be most productive in studying electronic portfolios? I felt that past research might provide us with some clues.

What Does Past Research Tell Us?

Looking for e-portfolio studies that might guide the design of new research, I did a new review of portfolio literature, paying particular attention to studies of preservice and inservice teacher portfolios. My objective was to find a small group of studies that used rigorous methods and displayed the features called for by Herman and Winters (1994): "attention to technical quality, to serious indicators of impact, or to rigorous testing of assumptions" (p. 1).

From a body of approximately 25 empirical studies of electronic portfolios, I selected six for analysis of methodology and findings. One study of traditional-format portfolios was included in the analysis because it complements one of the e-portfolio studies and sheds light on how *student* portfolios might be used for teacher professional development. In choosing these particular studies for analysis, I do not mean to suggest they are superior to others done during the period—there is a certain arbitrary element to my choices, and, undoubtedly, there are numerous high-quality studies of which I am unaware. These were chosen because I felt each revealed something useful about portfolios and about methodologies for studying them.

Using a framework derived from Herman and Winters (1994), but adapted for portfolios in a digital format, I looked for evidence of electronic portfolios' technical quality, implementation effects, fairness, feasibility, and tool effects.

Analysis was guided by these questions: How did particular studies use theoretical frameworks to ask important questions about portfolios? What methodologies and instruments for data collection yielded useful information about electronic portfolios? What might these studies tell us about directions for future e-portfolio research?

In this article I discuss the methodology of each study, highlighting particular aspects of their design and summarizing major findings. In the Conclusion section I use analysis of the selected studies to suggest directions and methods for electronic portfolio research, placing my own ideas in the context of an educational technology research agenda proposed by leaders in the field.

Analyzing Selected Research on Teacher Portfolios

Herman and Winters (1994) argued that we need evidence in four main areas to certify the soundness of portfolio assessment: (a) technical quality, (b) implementation effects, (c) fairness, and (d) feasibility. I have adapted these characteristics to apply not only to assessment portfolios, but also to those whose primary purpose is learning.

I added one additional category for analysis of research on digital portfolios. In investigating electronic portfolios, the manner in which the technological tool affected electronic portfolio process and product ought to be considered. I call this feature *tool effects*. In evaluating tool effects, one ought to begin with the question: What unique contribution did this tool make? Did the technology enable us to do something that we could not achieve without it?

These five criteria provide a framework for closely examining selected portfolio research. I begin my analysis with four studies that shed light on the technical quality of electronic portfolios; discussion of research relat-

ing to portfolio implementation effects, fairness, and feasibility follows. Consideration of tool effects is interwoven in each category.

Evidence of Electronic Portfolio Technical Quality

What do we mean by technical quality in portfolios? Herman and Winters (1994) identify the two core elements of psychometrics—reliability and validity—as key indicators of quality when referring to assessment portfolios. If, on the other hand, a portfolio's primary purpose is to foster learning, I suggest technical quality would lie in its capacity for prompting and structuring deep learning.

What do we know about the technical quality of electronic portfolios? I begin with a study by Derham (2003) that investigated factors of most concern for assessment portfolios—their reliability and validity—then focus on three studies of electronic portfolios used primarily for learning purposes: Avraamidou and Zembal-Saul (2004), Hartmann (2003), and a related study by Hartmann and Calandra (2004).

Technical Quality in Assessment Portfolios

A limited number of studies have considered the reliability and validity of traditional-format student portfolios (e.g., Gearhart, Herman, Baker, & Whittaker, 1993; Herman & Gearhart 1993; LeMahieu, Gitomer, & Eresh, 1995; Supovitz & Brennan 1997; Supovitz & MacGowan, 1997); the reliability and validity of electronic portfolios has yet to be established. A study by Derham (2003) is an important step in that direction.

Methodology. Carol Derham's dissertation research was an investigation of the reliability and validity of a newly-developed digital teaching portfolio, the Digital Portfolio Assessment of Teaching Competencies (D-PATCO). This portfolio was designed to assess the instructional competencies of preservice teachers. Derham examined evidence of the D-PATCO's psychometric properties based on a number of factors: test content (measured by expert opinion), relations with other variables (other preservice teacher assessments), and reliability estimates (internal consistency and interrater reliability). Data were collected from 30 preservice teachers during the course of four semesters and analyzed using multiple methods, including Pearson product-moment correlation coefficients, Cronbach's alpha, and Cohen's kappa coefficient.

Findings. Findings indicate that assessment of instructional competence is possible using a digital preservice teacher portfolio. Derham found that although D-PATCO demonstrated theoretically acceptable relationships with several other assessments of teacher competency and a generally positive expert review, there were weaknesses in the D-PATCO assessment tool: low inter-rater reliability and inadequate evidence of preservice teachers' content knowledge.

Derham reports that four key conclusions can be drawn about portfolios: First, it is feasible to develop and implement a digital portfolio that is adequate in assessing a majority of widely adopted standards for beginning teachers. Second, the D-PATCO assesses pedagogical knowledge and skills in a way comparable to grades in methods courses and scores on Praxis II. Third, this measure does not address the full breadth of preservice teachers' content knowledge.

Research such as Derham's helps us determine the technical quality of assessment portfolios. Avraamidou and Zembal-Saul (2004) shed light on how electronic portfolios can be used for learning.

Technical Quality in Learning Porfolios

Avraamidou and Zembal-Saul studied the Web-based electronic portfolios of two prospective elementary science teachers. Findings in this study help us verify that an electronic portfolio can foster deep learning and indicate conditions of significance in structuring it. Their methodology may be useful for other researchers to consider.

Methodology. Research was guided by theories suggesting that portfolios could be used to support preservice teachers' reflective thinking. Avraamidou and Zembal-Saul theorized that the Web format would facilitate complex interconnections between participants' personal philosophies for teaching science and multimedia evidence used to support those claims.

Multiple sources of data were used to investigate the nature of preservice teachers' understandings of the teaching of science and the manner in which task and technology supported thoughtful reflection. Two types of data were drawn from participants' Web-based portfolios: three versions of participants' philosophies for teaching science developed over time, and the reflective statements that accompanied each (i.e., participants discussed what changes were made in the different versions and explained why).

Three techniques were used to analyze the data: pattern-matching, explanation-building, and time-series analysis (Yin, 1984) as well as content analysis done on the reflective statements. The way participants used the capabilities of the Web format for displaying multimedia and hyperlinking was also carefully investigated.

Findings. Data analysis revealed evidence of learning and professional development in three areas:

- Making connections between university coursework and field experiences.
- Developing reflections from descriptive to explanatory
- Engaging in reflective and metacognitive activities

The researchers also reported that participants' portfolios displayed growth in pedagogical content knowledge for teaching science: participants' philosophies demonstrated that they had become more sensitive to children's thinking, to connecting physical engagement of children with conceptual aspects of learning, and focusing on teaching science as inquiry.

Avraamidou & Zembal-Saul make an interesting connection between the nature of the task and the affordances of the technology: (a) hyperlinking is used by portfolio authors to make non-linear, dynamic representations of their science teaching philosophy, and (b) the public nature of Web publishing makes thinking visible to a large audience—which motivates portfolio authors to produce their best work and enables them to give and receive feedback from a wide audience. These tool effects could not have been achieved without Web technology.

What is going on cognitively as teachers reflect on theory and practice, as they did in Avraamidou & Zembal-Saul's study? Christopher Hartmann (2003) provides us with a conceptual framework for teacher cognition and more evidence of what features of task and setting are important for developing professional "habits of mind." Hartmann's study is yet another example of the kind of systematic research we can use in documenting the technical quality of learning portfolios.

Methodology. In dissertation research, Christopher Hartmann (2003) investigated how seven prospective teachers of secondary mathematics learned to represent their teaching practice in an electronic portfolio. Hartmann uses Goodman's (1978) theory of rendering as a conceptual framework for understanding the process of teacher reflection on practice.

Data were gathered over two semesters of portfolio work from multiple sources: two semi-structured interviews, one focus group interview, observation of a portfolio seminar presentation, and three versions of the portfolio collected at different times during the process. Using "critical incidents of practice" as the unit of analysis allowed Hartman to triangulate across different data sources—each incident having been chosen for analysis because it appeared during an interview and also in the form of portfolio evidence. Analysis was by means of constant comparative methodology. Close examination of portfolio content was central to his investigation.

Findings. Hartmann's findings suggest that learning to render one's practice is cognitive scaffolding for preservice teachers as they develop the habits of mind necessary for them to grow toward high-quality mathematics instruction. Powerful learning occurred when participants were asked to render a single lesson multiple times (a finding similar to Avraamidou and Zembal-Saul).

Hartmann also suggests that establishing the portfolio as the beginning of a professional continuum of rendering and sharing one's practice gave portfolio authors an intrinsic purpose for portfolio authoring—a factor important for preservice teachers to make connections between their teaching experiences and university coursework. He emphasizes that much of the power of the portfolio in his study was due to the manner in which it was situated in a professional learning community.

In collaboration with Calandra, Hartmann did additional analysis of his corpus to investigate how technology impacted learning in a community of practice (Hartmann & Calandra, 2004). This analysis enabled the researchers to document how portfolio design fostered the development of community among the seven participants and how technological innovation disseminated through the group. Hartmann and Calandra point out how technological innovations enhanced portfolio authors' capability for representing their teaching of mathematics, and document tool effects.

Summary: Evidence of Technical Quality

The three studies analyzed provide evidence of electronic portfolios' technical quality as assessment and learning devices. Can portfolios be used to assess teachers' knowledge and skills with reliability and validity? Derham's findings suggest they have that capability. Can portfolios prompt deep learning? Avraamidou and Zembal-Saul 's research provides evidence that they do: "Our findings strongly suggest that prospective elementary teachers' learning could be enhanced through the Web-based portfolio development, which engages them in reflective and meta-cognitive activities about their views of science teaching and learning" (p. 438).

How can electronic portfolios prompt learning? Hartmann's findings indicate they do so most powerfully when constructed in a learning community. Both studies suggest that engaging preservice teachers in a recursive task requiring them to justify their beliefs, values, or practices with evidence from theory and field experience prompts reflection and results in significant learning. Features of electronic portfolio technology can support learning community and structure meta-cognitive activity.

What do these studies tell us about methods for researching electronic portfolios? Although methodology varied, each study defined clear research questions grounded in theory. Data were collected systematically from multiple sources and triangulated to establish its trustworthiness (Lincoln & Guba, 1985). Portfolio content was carefully analyzed.

Evidence of Electronic Portfolio Implementation Effects

Herman and Winters called for research to document the effects of portfolio implementation. Two studies of portfolio authoring in P–12 settings present some interesting findings about the effects of portfolios when elementary students and their teachers are engaged in the process of portfolio authoring. These studies are of note methodologically because they were located in P–12 classroom contexts, were conducted over an extended period (1–3 years) and use observational data in addition to interviews.

Implementation Effects of Learning Portfolios

Mumbi Kariuki (2001) studied preservice teachers who had been provided with laptop computers for use during a year-long internship experience in an elementary school. Each preservice teacher worked together with an elementary pupil to develop an electronic portfolio for the pupil.

Methodology. Fifteen preservice teachers, two mentor teachers, and fifteen elementary students participated in the Kariuki study, which lasted for the duration of a school quarter. Participant observations and in-depth interviews were conducted to investigate how the preservice teachers used the laptops and the effect of this use.

Findings. Findings in this study were that laptops gave preservice teachers quick access to technology, provided them with an opportunity to develop confidence in the integration of technology into teaching, and enabled them to become co-learners with their students. Elementary pupils also benefited: they displayed greater enthusiasm and motivation for learning; they had an opportunity not only to develop technology skills, but also to take on a mentoring role with an adult. Construction of an electronic portfolio by students and preservice teachers in an elementary classroom also provided the students' own teachers with a model for how technology can be used, enhancing their professional development.

The findings suggest that providing an opportunity to use technology with elementary pupils in a non-threatening setting is one way to prepare teachers who can integrate technology in their own classrooms. The study recommends the use of a project-based approach, such as electronic portfolios, when preservice teachers are provided with access to technology. In this case, the tool made a difference—it helped both preservice and inservice teachers develop new technology competencies and enabled both teachers and students to construct e-portfolios.

Although Judith Ellsworth (2002) did not do research on electronic portfolios, I include them in this analysis because her methods and findings are similar to Kariuki (2001): they shed additional light on the effects of implementation in a P–12 setting and show how student portfolios can result in teacher learning. Ellsworth's study is sensitive to the systemic effects of portfolio adoption in a school.

Methodology. Ellsworth's research was a three-year case study of an elementary school in which student portfolios were implemented as part of a comprehensive school reform effort. The study documents the specific role of portfolios in helping teachers at the site confront the discrepancies between what they thought they had taught, and what students had actually learned. The study also addressed the larger issues of teachers' changing conceptions of instructional practices and professional development needs resulting from a reform process.

Research was based on a phenomenological perspective, which seeks understanding from the perspective of the participants and is based primarily on descriptive data. Data sources included participant observation and in-depth interviews.

Findings. Findings indicate that portfolios can help teachers come to a deeper understanding of their professional practices. In this case, teachers gained a more comprehensive view of student learning by means of their portfolios. Teachers reported that no other form of assessment provided them with as much information for reflection.

Researchers noted that evidence from student portfolios was used by teachers to analyze and improve their instructional practices. Teachers were observed questioning their previous assumptions about teaching and learning; they became more deliberate in questioning the rationale for their instructional choices. Teachers also gave up some classroom control and began to conduct portfolio conferences with students and parents.

Ellsworth considers the greater involvement with parents to be a significant benefit of the portfolio: "Teachers recognized that the parents' reflection, along with the student's and the teacher's, created a more complete portrait of the student learner and provided another opportunity for teachers to reflect on instructional practices" (p. 351).

Portfolios had an effect on the school-wide reform effort: teachers began to make changes in classroom practice, to take on new school-wide responsibilities, and to take charge of their own professional development.

Summary—Portfolio Implementation Effects

Kariuki (2001) and Ellsworth (2002) contribute to our understanding of how P–12 student portfolio implementation can result in teacher learning. The location of this research in classroom settings over extended periods of time, the use of ethnographic methods, and collection of observational data make these studies worthy of note, and suggest productive areas for further research. We need more empirical research of this type to identify the effects of portfolio implementation in various settings, and with various tools.

Evidence of Electronic Portfolio Fairness

A third category Herman and Winters identified as important for researching portfolios is that of fairness. By this they mean, Whose work is it? Herman and Winters suggest that the amount of support a portfolio author receives might cast doubt on the fairness of the portfolio as an assessment device. If we are trying to establish what a given individual can do, widely differing amounts of assistance from peers, instructors, and others could be problematic. This issue is particularly significant when portfolios are used for high-stakes decision making about individuals or institutions.

This issue of Whose work is it? can be conceptualized in a different manner, however. Wineburg (1997) and others (e.g., Shulman, 1998) have argued that teacher assessment should occur in a collaborative context and that portfolio authoring ought to be a coached activity. The National Board for Professional Teaching Standards portfolio was deliberately structured to promote this kind of teamwork. Hartmann (2003) provides evidence that electronic portfolios can be made more effective by situating them in a professional learning community.

The concept of portfolio fairness also means something additional: Does the portfolio result in patterns of high or low performance for individuals of different genders or different socio-economic, ethnic, or racial groups? Wilkerson and Lang (2003) have explored the ramifications of this issue when portfolios are used as high-stakes assessments. They point out that portfolios must be shown to have no bias toward identifiable subgroups of the population, must allow for equitable treatment in the "testing" process, and must provide opportunities for all to learn whatever skills and knowledge are required for a satisfactory portfolio performance. If electronic portfolios are to be used for large-scale assessment purposes, we need research to verify that scores are not biased against students of different genders, SES status, race, culture, or even academic background.

Fairness in Assessment Portfolios

Derham's study (2003) indicates two areas of concern for e-portfolio fairness. She notes that programs wishing to use the D-PATCO and other digital portfolios will need to address the technological preparedness of their students if they wish to ensure fair and equitable assessment. Students will need not only the technological skills to author the portfolio, but also ready access to ancillary hardware and software. Derham found that participants in her study did not make use of lab resources for constructing their portfolios, but instead preferred to work at home. This is an issue not only of skill, but of economic resources as well. Will electronic portfolios disadvantage lower SES students?

We need additional research to answer this question and identify other factors that might interfere with equitable assessment. Because e-portfolio software differs so greatly in the level of technology skill required, research to determine what supports are needed for students to equitably construct e-portfolios must be sensitive to tool effects.

Fairness in Learning Portfolios

Empirical research is also necessary to identify what types of cognitive scaffolding and programmatic features are important for all students to benefit equally when a portfolio program has learning as its primary purpose. The many studies describing implementation of electronic portfolio programs in teacher education, if synthesized, could provide us with knowledge about how particular context variables interact with various e-portfolio tools.

Summary—Electronic Portfolio Fairness

Providing evidence of the fairness of electronic portfolios for assessment and learning will first require a conceptual understanding of the role of collaboration in portfolio authoring. Meta-analysis of portfolio assessment data could determine if there are patterns of high or low performance for individuals of different genders or different socio-economic, ethnic, or racial groups. Qualitative research is needed to document the features of tool and program that result in particular types of learning.

The extensive body of data accumulated by PT[3] projects with electronic portfolio programs could provide valuable information about fairness in assessment and learning portfolios. A summit of PT[3] leaders (Thompson, 2005) recently called for a synthesis of knowledge from PT[3] evaluation data and for the design of long-term, cross-project instrumentation for metadata analysis. Additional research on NBPTS portfolios might also help us understand the role of portfolio support materials and professional collaboration for electronic portfolios.

Evidence on Electronic Portfolio Feasibility

Herman and Winters (1994) called for research in one final category: portfolio feasibility. They identified a host of challenges making portfolios difficult to implement successfully in P–12 contexts:

- Portfolios make substantial demands on teacher and student time
- Teachers must learn new assessment practices
- Appropriate portfolio tasks and rubrics must be devised
- Portfolios require a culture of inquiry and student reflection on their own learning processes
- Teachers must take on new roles

Many of these challenges apply also to teacher education.

Electronic portfolios raise additional issues: Do portfolio authors have access to sufficient technology? Is technical support available and adequate? Do portfolio authors have necessary skills for using the hardware and software? And finally, what will it cost to provide all of these supports? Electronic portfolios will not be feasible for assessment or learning unless these issues are addressed.

Wilkerson and Lang (2003) have alerted teacher education programs to a host of psychometric, legal, and practical issues that must be faced when one seeks to use electronic portfolios for assessment and certification of teachers. My own research on preservice teacher portfolios (Carney, 2001, 2002, 2003) suggests other issues and dilemmas. Electronic portfolios may not prove feasible as devices for assessment or learning if we do not recognize their many challenges.

Feasibility of Assessment Portfolios

The feasibility of using portfolios for assessment may depend on how successfully we deal with a host of psychometric, legal, and practical factors. When portfolios are used for large-scale assessment, as they often are in teacher education, feasibility becomes a pressing concern. Wilkerson and Lang (2003) point out that portfolios used for certification or other high-stakes decision making must be psychometrically sound, or schools, colleges, or departments of education may be subject to legal challenges. Although not an empirical study, Wilkerson and Lang's cautions are worthy of careful consideration for the design of research on portfolios used for high-stakes assessment.

Wilkerson and Lang (2003) cite arguments from the literature, pointing out the problems associated with portfolios in a high-stakes testing environment: validity, reliability, fairness, excessive time burdens, and

portfolios' loss of value as a means to improve learning. Although they identify eight requirements for the use of portfolios as certification "tests," Wilkerson & Lange suggest that portfolios may be more appropriately used for formative assessment in support of learning rather than as a summative certification device. They assert that the most feasible use of portfolios for teacher assessment may be in amassing artifacts of P–12 student work to demonstrate a teacher's capacity for designing effective instruction.

Much more empirical research will be needed to make the case for electronic portfolios as summative assessment devices.

Feasibility of Learning Portfolios

Is it feasible to use electronic portfolios for preservice and inservice teachers if their primary purpose is learning, and assessment is formative? My own research (Carney, 2001) provides some evidence of how electronic portfolios function in that capacity.

Research was designed as a collection of in-depth studies of the portfolios completed by six candidates for certification as secondary teachers in a Masters in Teaching program. At the time they were engaged in portfolio authoring, participants had just completed student teaching and were in the final quarter of their program.

Although the portfolio at this university was a degree requirement assessed by means of a tri-level rubric, its primary purpose was learning, and assessment was formative: all students were expected to achieve at least a Standard level on the assessment rubric and had multiple opportunities to re-do work until it was considered satisfactory. While assembling their portfolios, students participated in a portfolio seminar where they received support and regular feedback from the seminar instructor, peers, and a teaching assistant assigned as mentor. A key portfolio goal was to structure reflective thinking.

Methodology. Research was an effort to understand how preservice teachers conceptualized themselves, represented their knowledge, and communicated it to others by means of electronic and traditional portfolios. The study's framework was drawn from theories conceptualizing teacher knowledge (Shulman, 1986, 1987) and tool-based socio-cultural activity (Vygotsky, 1981). I considered how the tool chosen for portfolio authoring interacts with other artifacts in the setting to influence authors' sense of audience and purpose, and how audience and purpose affected portfolio form and content. Artifacts within the portfolios were carefully analyzed for teachers' pedagogical content knowledge (Grossman, 1990; Shulman, 1986, 1987; Wilson, Shulman, & Richert, 1987).

Case study methodology was used to develop six cases; they included both a paper and an electronic portfolio from three different secondary subject areas: language arts, social studies, and science (physics). Data were collected by means of participant observation, think-aloud commentaries, participant interview, and examination of the Teacher Education Program portfolio requirements and rubrics.

Data analysis was ongoing, as recommended by Miles and Huberman (1994). Each individual case was reviewed and coded into units of meaning, beginning first with descriptive and interpretive coding, and working finally into pattern coding (Miles & Huberman, 1994). Two separate cross-case analyses of the data were subsequently completed, comparing the two participants within each subject matter in two groups based on whether they had used traditional or electronic tools for portfolio authoring. The manner in which technological tools were used to accomplish particular representational or cognitive activities was carefully investigated and described.

Findings. Primary findings include the following assertions:

1. Trying to achieve multiple purposes with a portfolio can be problematic if it forces the author to write for multiple audiences with different information needs and beliefs. Portfolios written for multiple audiences were less successful in achieving their purposes than were portfolios written for one audience. The exception was when audiences were perceived to have similar beliefs and goals.

2. Defining a potentially critical audience can inhibit preservice teachers from honestly representing themselves as teachers and engaging with the problems they faced as student teachers. Making the portfolio a high-stakes assessment or suggesting that it might be a device for obtaining a job makes it unlikely that the portfolio will be used for deep reflection on practice.

3. Portfolios can provide a vehicle for documenting teachers' pedagogical knowledge. How teachers transform subject matter knowledge into curriculum, representations, and instructional strategies for teaching can be demonstrated in portfolio artifacts and reflective entry slips. Differences in PCK indicative of differing levels of teacher knowledge can be documented. Enunciating a purpose for teaching one's subject may be as important a theoretical stance as formulating a philosophy of education.

4. If we wish all aspects of pedagogical content knowledge to be represented in portfolios, including strategies for technology integration, portfolio recipes must properly scaffold the activity. Portfolio authors were focused more on teacher action than student learning. With little classroom experience, this category of pedagogical content knowledge is likely to be deficient; however, the consistent lack of reflection on individual student learning suggests portfolio recipes failed to structure it.

5. The manner in which a tool mediates activity is a complex process of individual and social interaction. Any program that seeks to use portfolios as devices to document teacher knowledge and promote reflective practice must attend to the manner in which technological and psychological tools are used. Both tools and people in the setting interact to shape portfolio form and content. Small features of each tool, in concert with personal interactions, can have a powerful effect.

6. There are significant differences between traditional paper and electronic Web portfolios. Presentation devices have distinctive profiles based on the affordances and constraints of the tool (Gibson, 1979). Many of its affordances of the electronic medium are not yet being used to advantage. One of the most notable affordances of electronic portfolios seems is their capacity for continuing professional development.

Summary—Electronic Portfolio Feasibility

The use of electronic portfolios for teacher assessment and learning may depend upon how successfully we recognize and deal with the many psychometric, legal, and practical issues they entail. Evidence suggests portfolios may be more feasible as formative assessment devices in support of learning rather than for summative assessment. Features of electronic portfolio software can interact with other tools in the setting to shape portfolio form and content in subtle and unexpected ways—which adds to the complexity of the planning process, and the necessity for research sensitive to contextual variables.

Conclusion

What can we learn from the seven empirical studies examined here? How did these studies use theoretical frameworks to ask important questions about portfolios? What methodologies and instruments for data collection yielded useful information about electronic portfolios? What do they suggest about directions for future e-portfolio research? Insights from my analysis are communicated in the form of five assertions below. In making these statements, I also draw upon recommendations by educational technology and teacher education leaders.

Assertion 1: Important questions about portfolios should be derived from robust theories of cognition, learning, motivation, tool use, and other relevant concepts.

Whether quantitative or qualitative methods are used, research on electronic portfolios ought to be grounded in theory. Several of the studies analyzed in this article are clearly grounded in theory (e.g., Carney, 2001; Hartmann, 2003): research questions arise from theoretical issues, and findings are related back to theory. Other studies may have been theory-driven, but published reports failed to make the connections clear.

In calling for a new millennium research agenda on educational technology, Robyler and Knezek (2003) remind us: "It is axiomatic that educational research should help address heretofore unresolved or poorly resolved educational problem(s), and that hypotheses should be derived from a theory base (p. 67)." In researching electronic portfolios, we must heed Maddux and Cummings' (2004) warning about fads in educational technology.

Assertion 2: Research on electronic portfolios ought to probe basic assumptions and claims about both portfolios and technology.

Studies analyzed here investigate the technical quality of portfolios, probing the claims of theorists who have proposed portfolios as devices for assessment and learning. Findings document that electronic portfolios can function as theorized, and indicate conditions for how they might achieve their purposes.

Many research studies of electronic portfolios have focused on methods of implementation, ignoring the question of why we should use the technology in the first place. In surveying the field, Nordrum, Shitaoka, and Steel (2005) note: "E-portfolios as they are currently used, are conceptualized and implemented too often as end products rather than as tools to improve the learning and teaching process" (p. 207). We need more empirical research that attends closely to whether electronic portfolios actually improve teaching and learning. Why should we use this technology? What learning or other desirable ends does it enable us to achieve that we couldn't do without it?

Assertion 3: Research on electronic portfolios should use rigorous methods and communicate findings in such a way that the contributions of methods are clear.

Leaders in the field of educational technology have called for greater rigor within all approaches to research (e.g., Robyler & Knezek, 2003; Strudler, 2003). Studies analyzed here suggest what those rigorous methods look like when applied to electronic portfolio research. Methodologies varied, and although some of these studies were more rigorous and systematic than others, all used instruments for data collection appropriate for their particular research questions, multiple sources of data, triangulation of evidence, and systematic analysis.

What are some of the methods that proved useful for studying portfolios? The complex manner in which teachers learn through portfolios is documented by think-alouds (Carney, 2001), careful analysis of portfolio content (Avraamidou & Zembal-Saul, 2004; Hartmann, 2003), and observational data from school settings (Ellsworth, 2002; Kariuki, 2001). The unique contributions and constraints of particular technological tools are carefully examined and described by Avraamidou & Zembal-Saul (2004), Carney (2001), and Hartmann and Calandra (2004).

Assertion 4: Research on electronic portfolios should be sensitive to context.

Several of these studies paid special attention to context—analyzing how social interaction and the various tools available for portfolio authoring interacted in a setting (Carney, 2001; Hartmann, 2003). Others used long-term ethnographic methods that described not only individual effects, but systemic ones as well (Ellsworth, 2003).

Berliner (2002) has noted that "good science" requires not only trying to capture valid and reliable evidence of improvement, but also attempting to explain the complex set of conditions that led to improvement. Electronic portfolio research must include both the analytic and systemic approaches recommended by Soloman (1991)—the analytic approaches to test specific theory, systemic approaches to capture the richness of events, and actions in complex social environments.

Strudler has cited Hall and Hoard (2001) in suggesting that an innovation configuration map might be used identify major components of innovations and describe observable variations for each component.

Assertion 5: Research on electronic portfolios should include more large-scale and long-term longitudinal studies; Mixed method and cross-project designs ought to be deliberately planned.

This analysis of electronic portfolio research has drawn primarily upon small-scale e-portfolios case studies, done during relatively short periods of time. More large-scale longitudinal research is needed. PT[3] leaders have called for the synthesis of data from PT[3] projects nationwide and more cross-project designs for meta-analysis (Thompson, 2005). Considering the large number of PT[3] projects with electronic portfolio programs, efforts of this type would greatly further our understanding of e-portfolios used for preservice teachers.

PT[3] leaders (Thompson, 2005) have also recommended following preservice teachers from induction through year three. E-portfolio research ought to follow this recommendation, seeking to determine the effect of preservice e-portfolios on beginning teachers' practices, and whether those practices result in improved P–12 student learning.

Final Commentary

Analysis of electronic portfolio research can tell us something about portfolios and about effective methods for studying them. Yet no matter how carefully selected, each study has limitations and deficiencies; it is only by amassing a body of empirical evidence that we can document electronic portfolios' technical quality, implementation effects, fairness, feasibility, and singular tool affordances.

Herman and Winters (1994) asserted, "Change alone is not enough—the quality of change and the efficacy of the new practices must be subject to inquiry." Many believe that electronic portfolios have the potential to capture and develop teacher knowledge in ways not possible with older technologies—but if teacher educators and technologists fail to critically evaluate uses of the device, we may find that the promise of portfolios has been perverted, and the device soon abandoned. Only good research can keep electronic portfolios from being another educational fad. Let us continue our inquiry.

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