Developing Pre-Service Teachers' Research Capabilities Using LAMS

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This paper examines the impact of a LAMS activity designed to develop the research-based thinking capabilities of pre-service teachers. Diploma of Education students were required to formulate a research question regarding an educational question of interest and then design a LAMS sequence that could be used to investigate their question. The approach resulted in small but significant shifts in students' perceptions of the importance of research in learning and teaching, as well as improvements in their understanding of research issues. The technology-enabled research designs that students created revealed a range of student difficulties, including the creation of a measurable question, alignment of the methodology with that question, and the effective selection and use of technologies to implement the research designs. Eighty-four percent of students surveyed indicated that they experienced success in creating a technology-enabled educational research study, and the same proportion indicated that as a result of the exercise they would be more likely to integrate research-based investigation in their professional learning practices.
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Keywords: LAMS, undergraduate research, teacher education, learning design

Introduction

Research-based learning is a learner-centred knowledge building exercise where learners "pursue their own new questions and lines of inquiry, in interaction with the knowledge-base of the discipline" (Jenkins & Healey, 2009, p.26, adapted from Levy 2008). There has been an increasing international emphasis on integrating research-based learning into the undergraduate curriculum (Boyer Commission 1998; Jenkins 2009; Jenkins and Healey 2009; Brew 2010). Evidence suggests that incorporating research into the undergraduate curriculum can result in improved learning outcomes, including improved academic performance and lower rates of university dropout (Justice, Rice et al. 2007), the development of students' critical thinking and reflective judgement (Bauer and Bennett 2003), enhanced problem solving capabilities and increased confidence in ability to conduct research (Seymour, Hunter et al. 2004), as well as epistemological development surrounding how scientific knowledge is formed (Ryder, Leach et al. 1999).

There appears to be an underrepresentation of research-based learning approaches in undergraduate education curricula compared to other discipline areas. For instance, a US study into the differences between undergraduate research experiences across faculties found that Education programs incorporated less research than any other discipline (Buckley 2008). While there are dozens of case studies and resources relating to the STEM subjects (Science, Technology, Engineering and Mathematics) in the Higher Education Academy's report on undergraduate research (Jenkins and Healey 2009), on the US Council on Undergraduate Research website (CUR 2010) and on the Undergraduate Research in Australia archive (Brew 2010), not one specifically relates to research-based learning in the field of educational studies (for instance pre-service teacher education).

This paper argues the importance of research-based thinking in the teaching profession and explains how the LAMS learning design system can be used to develop undergraduate education students' research capabilities.

Research-Based Learning

The Council on Undergraduate Research defines undergraduate research as "an inquiry or investigation conducted by an undergraduate student that makes an original intellectual or creative contribution to the discipline" (CUR 2010). Drawing from Levy (2008), Jenkins & Healey (2009) identify four main ways of engaging undergraduates with research and inquiry:

- *research-led:* — students learning about current research in the discipline
- *research-tutored:* — students engage in research discussions
- *research-oriented:* — students developing research skills and techniques
- *research-based:* — students undertaking research and inquiry.

These approaches can be differentiated by the degree of student ownership over the learning process, and the extent to which research processes are applied, as shown in Figure 1.
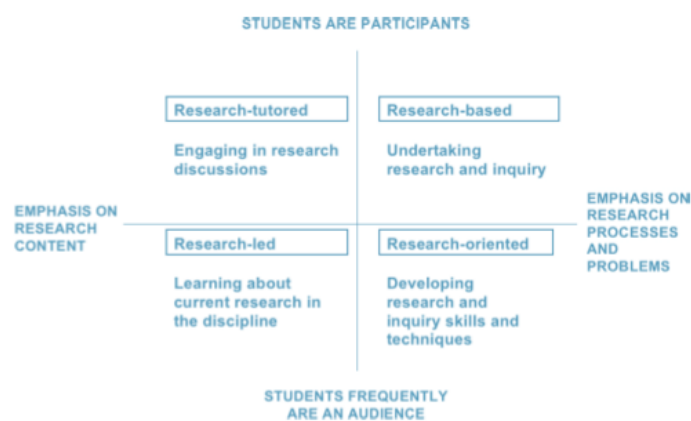
STUDENTS ARE PARTICIPANTS

| Research-tutored | Research-based |
| Engaging in research discussions | Undertaking research and inquiry |

EMPHASIS ON RESEARCH CONTENT

EMPHASIS ON RESEARCH PROCESSES AND PROBLEMS

| Research-led | Research-oriented |
| Learning about current research in the discipline | Developing research and inquiry skills and techniques |

STUDENTS FREQUENTLY ARE AN AUDIENCE

Figure 1: Types of undergraduate research and inquiry

Healy and Jenkins (2009) argue that too much of higher education relates to students as audience, and that students would benefit from spending more time as participants in research processes. It is proposed that in pre-service teacher education the vast majority of research related activity that students undertake relates to research-led learning. Students are expected to relate their assignments, essays and examination papers to prevailing literature and academics see this as a way to promote scholarship in their learning experience. Yet this approach sees undergraduate students as passive receivers of knowledge using the same transmissive pedagogy that most teacher educators criticise (using arguments such as those presented by Carroll 1998). While learning about current research in the discipline is an important starting point for developing critical and discriminating teachers, it is only through engaging in research discussions, developing research skills, and undertaking research and inquiry that our teachers of the future can become empowered to discern the most effective pedagogical approaches to suit their students and make scholarly contributions to the education field.

A research-based approach in teacher education is arguably as important as in any scientific discipline, if not more. Unlike many of the sciences where knowledge and principles are relatively stable from context to context, teaching is a highly complex discipline that is highly context dependent. This means that while the teacher can draw upon some theoretical frameworks to inform their practice, they may need to extrapolate, reinterpret, or redefine approaches depending on the specific circumstances of their students, classroom environment, school and community. That is to say, research-based approaches to teaching are *required* in order to be an effective teacher. According to one study, education students who work on research projects indicated more strongly than any other faculty that their undergraduate research experience helped them to develop their intellectual skills, their career and collaborative abilities, their research skills, their understanding of how knowledge is created, their ability write more clearly and effectively, and their capacity to work more effectively with others (Buckley 2008).

Using LAMS to enable students to create research designs, not only develops students' research capabilities but also develops their technology-based learning design thinking.

Method

In Week 8 of Semester 1 2010, Education students enrolled in the second year subject "ICT & Education" at Macquarie University completed a 90-minute lesson designed to develop their research thinking and capabilities. The lesson itself was designed as a LAMS sequence, which can be found at http://www.lamscommunity.org/lamscentral/sequence?seq_id=1093725. The lesson did not form part of the students' assessment for the subject.

After a brief discussion about why research might be important as a teacher, the students were informed that the lesson would involve them reflecting upon the value of research-based learning and teaching and designing a research study of their own. They then completed the following pre-lesson survey questions to act as a baseline for measuring their attitudinal shift:

1. It is important for education students to adopt a research-based approach when learning about teaching in their undergraduate studies (seven item Likert scale from Strongly Disagree to Strongly Agree)
2. It is important for practicing teachers to adopt a research-based approach to teaching when teaching their classes (seven item Likert scale from Strongly Disagree to Strongly Agree)
3. What are the advantages of adopting a research-based approach to professional learning as a practicing teacher?
4. What are some issues to consider when adopting a research-based approach to professional learning as a practicing teacher?

The body of the lesson consisted of the following three phases:

A. *Devising research questions* – students brainstorm educational research questions of interest as part of an open-ended Q&A activity.
B. *Designing the research study* – students write (in plain text) the design of a research study including the question to be investigated and the approach to investigation (method).
C. *Developing the research study* – students develop a LAMS sequence that could be used to conduct their research study and then upload it.

Each stage was accompanied with whole class discussion that addressed pertinent issues relating to the phase, such as what constitutes a well-designed research question, factors and processes that affect the quality of a research study, and how a research design might be mapped to the LAMS learning tools. In the *devising research questions* phase students were allocated to groups of two or three people to discuss research questions of interest to them (before posting their ideas to the online sequence). In the *designing the research study* phase students were asked to pick a question of interest to them that they might be able to implement using LAMS, and were also encouraged to document any issues that they envisaged might arise during the implementation of their methodology. In the *developing the research study* phase students were provided with a partial demonstration of how a research method might be implemented as a LAMS sequence, based on one of the student examples. This included a discussion of how grouping, branching, voting, and survey tools might be used to conduct research processes. Students were instructed that they did not need to populate all of the content of their sequences (for instance all instructional materials and quiz items) but rather focus on developing the framework of activities for conducting their research-based lesson.

Of the 90 minute lesson approximately 10 minutes was spent on completing and collaboratively reviewing phase 1, approximately 15 minutes was spent completing and reviewing phase 2, and approximately 20 minutes was spent completing phase 3. Students were also asked a post-lesson survey consisting of the same questions as the pre-lesson survey, allowing reliable measures of attitudinal shift to be gauged.

Students were then asked to complete an optional post lesson reflection activity that consisted of the following questions:

1. What did you learn from this activity?
2. Which phase of creating a research study did you find most difficult? (devising the research question, designing the research study, or developing the research study)
3. Why did you find that phase harder?
4. What sort of support could have been offered to make devising, designing and developing a research study easier in this lesson?
5. I was able to develop a research study in this lesson (seven item Likert scale from Strongly Disagree to Strongly Agree).
6. LAMS enabled me to more quickly and easily develop a research study than if I did not have this system (seven item Likert scale from Strongly Disagree to Strongly Agree).
7. As a result of this lesson I am more likely to adopt research-based approaches when I become a teacher (seven item Likert scale from Strongly Disagree to Strongly Agree)
8. Any other comments.

Of the 62 participants in the study, 25 volunteered to complete the optional post-lesson reflection activity.

All Likert scale datum were analysed statistically using a translation of category responses to numerical data (Strongly Disagree = 0, Disagree = 1, Mildly Disagree = 2, Neutral = 3, Mildly Agree = 4, Agree = 5, Strongly Agree = 6). While caution need be exercised when interpreting ordinal to cardinal data transformations, it should be noted that this form of stochastic analysis commonly occurs in analysis of participant perceptions.

Results

Shifts in student perceptions of research-based approaches

The pre-lesson survey responses indicated that before even conducting the lesson, pre-service teachers generally agreed that it was important for research-based approaches to be integrated into their curriculum ($\bar{x}$=4.79, s = 0.99, average response value between Mildly Agree and Agree). The post-lesson responses to the same question resulted in an even higher average rating of the importance of research-based approaches in the undergraduate curriculum ($\bar{x}$=5.05, s = 0.73, average response value between Agree and Strongly Agree). A two-tailed paired difference t-test of pre and post lesson scores indicated that this difference in mean scores was statistically significant (t = -2.34, p = 0.022, $d.f.$ = 61).

The average pre-lesson survey rating relating to the importance of integrating research-based approaches in their classes once they became teachers was not as high as it was for them to receive those approaches in their undergraduate curriculum ($\bar{x}$=4.66, s = 0.85, average response value between Mildly Agree and Agree). The post-lesson responses regarding the importance of teachers adopting research-based approaches in their classes was again more highly rated than the pre-survey responses to the same question ($\bar{x}$=5.03, s = 0.79, average response value between Agree and Strongly Agree). A two-tailed paired difference t-test of pre and post lesson scores indicated that this difference in mean scores was statistically significant (t = 2.98, p = 0.002, $d.f.$ = 61).

Advantages and issues relating to research-based professional learning for teachers

As expected students could identify general benefits of research-based professional learning before completing the learning task, such as "improves the quality of teaching". However before even completing the lesson the pre-service teachers were also able to identify a range of specific advantages relating to adopting research-based professional learning approaches, for instance:

1. *"keep up to date with new pedagogies, basing ideas on research"*
2. *"you, as a teacher, explore the views and opinions of peers and academics"*
3. *"trying out new emerging methods or peer reviewed ones"*
4. *"understanding the methods by which students learn and comprehend concepts"*

5. *"knowing when and how to apply different approaches and situations"*
6. *"constantly improving on your own practice (reflective practice)"*
7. *"continuous life long learning; stimulating your interest and challenging your assumptions"*

There was a small but discernable improvement in students' post-activity responses to the survey questions compared to the pre-activity responses. Several students were able to raise more points and offer a wider variety of advantages relating to applying a research-based approach to professional practice. Benefits raised or elaborated in the post-activity responses that were not raised in the pre-activity responses included:

1. *can contribute your own research to assist in others' professional development*
2. *by adopting this approach you role-model to others who just go-with-the-flow*
3. *keeping an open mind, continuously seeking to learn more and updating your knowledge (not simply walking into a classroom with one idea of how you will teach and sticking to it*

There was a more noticeable difference in the post-activity issues that students raised with relation to research-based professional practice. Before completing the research-based learning activity the overwhelmingly most commonly identified issue associated with research-based professional learning was time; conducting research-based professional learning was perceived to be an onerous undertaking in light of the other ongoing responsibilities of the classroom teacher. Several students also identified pragmatic issues, such as acquiring parental consent, any funding that might be required, staff-room politics that may arise. Only seven students identified specific methodological issues such as reliability, validity, ethics, and the like.

After completing the learning activity more students identified particular methodological considerations that would need to be taken into account in order to conduct quality research investigations (15 students). Some students also articulated the way in which the research method influenced the utility of the study, posing issues as questions such as "How much evidence do you need in order to draw valid conclusions?" and "Can you generalise results to other classes of different age and abilities?" Students also acquired a greater appreciation of the complexity of conducting research with comments such as "it is hard to control for all extraneous variables", and that there were "a lot of variables to consider (abilities of student, stage of learning)".

Phase A: Pre-service teacher's research questions

The sixty-two students posed a total of 159 research questions that were of interest to them ($\bar{x}$ = 2.56 per student). There was a wide variety of question types from the broad and ill-defined to specific and measurable. Examples include:

1. *How to make teacher's teaching more interesting and motivating*
2. *How do students respond to different forms of assessment?*
3. *To what extent should norms-based assessment be used, if criterion-based assessment is more valuable for individual students?*
4. *Should the teacher be 'friends' with the students?*
5. *Value of discovery learning vs tradition (difference in time spent achieving same outcomes)*
6. *Does group work assignments develop students' learning better than individual assignments?*
7. *Do classrooms with technology get better results than classrooms without technology?*
8. *Effectiveness of virtual experiments As a replacement for real science experiments*
9. *Relative effectiveness of computer mediated mind mapping versus physical pen and paper mind mapping creation*
10. *Can collaborative/constructive technologies like Wiki's and blogs be applied to students with Autistic Spectrum Disorder?*

Common themes of interest embedded in students' research questions included motivation, differentiation of the curriculum, assessment, relative effectiveness of different pedagogies, and the effectiveness of technology in the classroom. Some attributes of the students' research questions (notably the specificity and duration) impacted upon the ease with which the question could be investigated.

Phase B: Pre-service teachers' methodologies

For this section students generally wrote between 60 and 150 words, including the brief summary of their research question. Some students were able to identify a researchable question and provide a methodology that directly addressed the question, for instance:

> *Question to be investigated: Do students retain knowledge better from online or offline sources.*
> *Approach to investigation:*
> *1. Students are divided into two groups, (1) reads a passage offline, (2) reads the same passage online on a website with pictures.*
> *2. Students are quizzed about their knowledge through 10 short answer and 10 multiple choice questions.*
> *3. Students swap over and repeat steps 1 and 2 with a different source.*

Others struggled to define a contained question or provide a method that could be used to structure a research study, for instance:

> *Question: How would you make student learning (lesson plan) more fun and constantly being creative, interesting and engaging throughout the lesson?*
> *Approach:*
> *- understanding the students knowledge of technological tools.*
> *- catering to all learning styles (continuously)*
> *- train students on one tool each lesson.*
> *- Introduce tools such as Wiki, Podcast, LAMS, Computer Games, Slide Shows or even facebook or twitter which would be more familiar to a student and easy to use and adapt to.*
> *- Let students work in groups to create their own LAMS or WIKI*

Many students struggled to align their research methodology with the question. Often this was because students had very broad questions that were addressed using very specific methodologies. Several students decided to investigate their question by conducting a survey of learner or teacher perceptions rather than by using outputs of learning as evidence (for instance when investigating which assessment strategies would be more effective). Other students did not provide details about the different steps they identified in the research process. Seven students out of sixty-two identified the utility of analysing related research that had already been conducted.

In terms of issues, some students only identified issues related to teaching the classes themselves, not to conducting effective research. For other students, having to define a concrete methodology stimulated far more in-depth analysis of the issues associated with research-based professional practice than they identified in either the pre- or post- survey.

Phase C: Pre-service teachers' technology-enabled educational research lessons

There was a wide variety in the quality of research-based lessons that the students developed, in terms of the scope of the sequences and the sophistication of the research designs embedded therein. Some students struggled to create research designs that used the affordances of the technologies at hand to collect evidence relating to their research question. Often this was made more difficult by the lack of focus in the research question itself. Consider the sequence in Figure 2 that addresses the research question: "Where could technology go in the future?" The sequence commences with an initial Noticeboard to provide task instructions, followed by a Grouping that could be used to apply different treatments to different students. However the Grouping setting was for groups of 1, which had no net effect when applied to the subsequent Mindmap and Q&A activities. The Mindmap and Q&A activities were ways of collecting data relating to student perceptions of where technology could go in the future, but they did not facilitate the collection of data that could provide evidence from which educational research conclusions could be drawn.
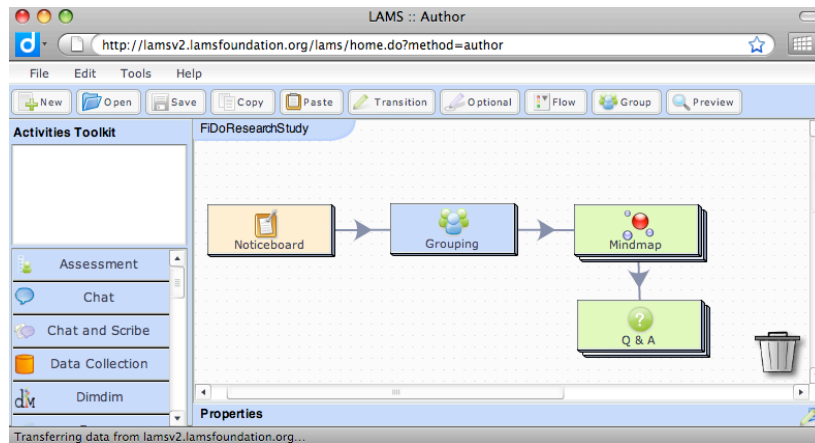
**Figure 2: Technology-based research sequence addressing the question
"Where could technology go on the future?"**

A range of errors were evident in students' technology based educational research designs, including:

1. Using the wrong tool for a specific purpose (for instance using a Notebook instead of a Noticeboard to present information, or a Task List to collect student performance information)
2. Not applying groups to branches or inappropriately grouping activities
3. The data collected was inappropriate or insufficient to address the research question (for instance only collecting data about what students thought of different teaching approaches without comparing the different strategies and the actual outputs from student learning)
4. Compounding of treatments potentially leading to confounding of effecting variables
5. Inconsistent pre and post treatment data collected resulting in inferior effect measurement
6. A disconnect between the question being researched and the activities contained within the sequence (spuriously using technologies without specifically trying to compare certain features or address a certain question)
7. Providing tasks that were at an inappropriate level for the target audience.

Several sequences also had limited amount of content populated within the activities, which made it more difficult to determine how the sequences related to the research questions being investigated.

On the other hand some students were able to develop sequences that applied reasonably sophisticated research designs. For instance, the sequence shown in Figure 3 uses the Grouping and Branching tools of LAMS to randomly administer two different treatments to students; one half of the class is supplied with teacher-selected resources while the other half of the class is required to independently source resources. A Q&A activity is used to assess student learning, and the Voting tool is used to gauge student perceptions on which approach is best (as well as have them collaboratively reflect on the efficacy of the two approaches).

Distinguishing attributes of higher quality research designs included:
1. High quality research questions (for instance, socio-constructivist learning using resources and forum, data collection, chat and scribe, versus individual learning using noticeboards and content links provided in share resources)
2. Clear specification of the lesson (usually using noticeboards)
3. The extent to which research designs directly addressed the question
4. Using random grouping and branching to objectively compare different teaching strategies (sometimes with up to four separate treatments being compared)
5. Matching pre- and post-test forms to more accurately assess changes in understanding or attitude
6. Collection of both learning data (using assessment tools) and attitudinal data (using surveys and voting)
7. Collecting a range of learning data (from multiple choice to mindmaps) to assess the impact of pedagogical strategies on different levels of knowledge

8. Applying repeated trials of an experimental cycle using different topics to establish the extent to which effects were generalisable.
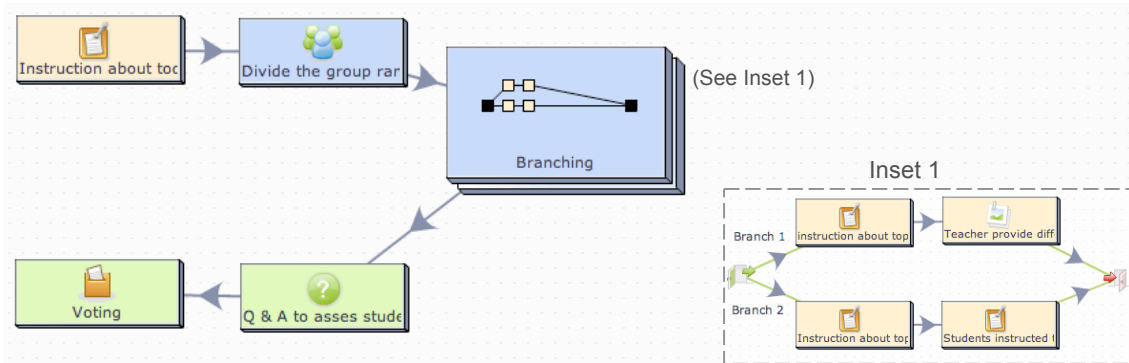

Figure 3: Technology-based research sequence addressing the question
"Is it better for the teacher to provide students with links to resources or for students to find them for themselves?"

Of the 25 students who volunteered to complete the post-lesson reflective questions, eight felt that the most difficult phase was devising the research study, six felt designing the research methodology was most difficult, and eleven felt that developing the research study using LAMS was most difficult. The majority of students who found devising the research question the hardest, five felt that this was the most difficult phase because they understood how it was intrinsically related to the research methodology and implementation. Students who found designing the research method hardest identified actualising the general concepts that had been identified in their question and working under time constraints as the main reasons. The eleven students who found developing the research study using LAMS the most difficult generally cited reasons relating to further concretising their study; when it came time to actually implement their design they needed to either think more deeply about how specific nature of the activities or how the design should be constructed so as to address the research question being investigated.

Student evaluation of the learning experience

Of the 25 students who volunteered to complete the post-lesson reflection, the majority (15) indicated that LAMS enabled them to more quickly and easily develop a research study than if they did not have the system. Twenty felt that they were to some extent able to develop a research study using LAMS. Twenty-one out of twenty-five students felt that they would be more likely to adopt research-based approaches when they became a teacher than before they had completed the lesson. Taken together these results indicate that students perceived the lesson as a positive and successful learning experience.

In response to the reflective question relating to the way in which the lesson could have been improved to support devising, designing, and developing a research study, students suggested providing a number of examples of questions and designs, more extensive discussion of research concepts, more group collaboration, additional technology support if required, and more time. One student suggested greater collaboration between teachers of the same discipline area for more context appropriate development of research approaches. Another student recommended providing fully worked examples that included data that had been collected and conclusions that had been drawn (as a way of demonstrating the utility of teachers engaging in research-based professional learning).

In response to the open-ended request for other comments, several students left positive comments about the learning experience. For instance:

- *I think it was a good activity to make education students more aware of what research can do for them as a teacher, both at this stage of their professional development and later on when they are practicing.*
- *I had always bagged research studies [due] to incomprehensibly high academia and now I have it tucked away as a wonderful reflective tool. Thank you.*

While some students qualified their positive comments with reflections about the challenges embedded in the process, not one student provided predominantly negative feedback about the lesson.

Discussion

The concrete nature of designing a study using technology allowed the quality of pre-service teachers' research designs to be rapidly assessed. Apart from using the wrong tools or configuring them correctly, the research sequences immediately revealed errors relating to the type of data being collected, the appropriateness of data for the question being researched, potential interference between factors, and the overall structure of the research sequence. In this way technology-based educational research sequences provide an efficient mechanism to assess and develop research design capabilities of students. The flexible nature of learning design tools such as LAMS also means that any mistakes inherent in students' research designs can be rectified without needing to redevelop the study from scratch. The extensive range of features embedded in the LAMS system meant that more capable students were able to demonstrate advanced research thinking by including sophisticated sequences of treatments and intelligent data collection forms.

A key purpose of the study was to raise students' awareness of the importance of research-based approaches to learning and how technology can be used to support this. Post lesson feedback indicated that the majority of students (84%) experienced success in developing the technology-enabled educational research study, and the same proportion were influenced towards using such approaches as part of their professional practice. The majority (60%) also perceived the utility of using technology to support research-based professional learning.

Future work involves investigating several questions relating to the development of undergraduate research capabilities that were raised in this study. For instance, do well-constructed research questions result in better studies? Do students who find the question design phase most difficult develop lower or higher quality studies? What are the relationships between students' ability to complete each of the phases? What assessment frameworks can be used to assess undergraduate research designs? Future work may also include using the data collected in this study as well as literature related to assessment of research in order to design a framework for assessing undergraduate students' technology enabled research designs.

Conclusion

It is imperative that our teachers of the future have the capacity to integrate research-based learning into their professional practice because of the context sensitive nature and rapidly evolving nature of teaching; without the capabilities to test new pedagogical approaches and understand their impact on learning, teachers have no way to determine the effectiveness of their strategies.

Learning technologies such as LAMS enable researchers to rapidly construct and conduct research studies by affording efficiencies such as embedded task specification, participant grouping, differentiated and controlled treatments, and digital data collection. Developing an educational research study using LAMS required that pre-service teachers concretize their research designs, encouraging them to think specifically and deeply about the concepts at stake and allowing the teacher to more easily assess their research capabilities. The 90-minute educational research design activity not only significantly increased pre-service teacher perceptions of the importance of research in their own education, but also in the education of their students. The lesson led to the majority of students seeing how technology could be used to facilitate educational research, feeling successful in the technology-based research development process, and more likely to adopt research-based approaches when they become teachers.

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