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Optimising Personal Audience Response Systems technology to enhance student learning in teacher education lectures

Terry de Jong
Edith Cowan University, Perth, Australia
t.dejong@ecu.edu.au

Jenny Lane
Edith Cowan University, Perth, Australia
j.lane@ecu.edu.au

Sue Sharp
Edith Cowan University, Perth, Australia
s.sharp@ecu.edu.au

Pat Kershaw
Edith Cowan University, Perth, Australia
p.kershaw@ecu.edu.au

New technologies are integral to the lives of most 'Generation Y' students. They tend to be visually-oriented learners, prefer relaxed and socially conducive learning environments, and anticipate engaging, relevant, and authentic learning experiences. Work environments commonly assume prospective employees to be technologically competent. In particular, school teachers are expected to embed new technologies in their teaching. As teacher educators at Edith Cowan University mindful of these imperatives we recently trialled a Personal Audience Response System (PARS) in our education lectures to enhance student engagement and learning. This technology is widely used in higher education in North America and increasingly so in Australian universities. It permits students to give instant individual responses to questions posed. The data are automatically analysed and displayed to the students. Our evaluation of the role of PARS in our lectures indicated compellingly that it enhanced student engagement and learning. We identified four discernable learning processes that the technology appeared to enhance for our students, notably: expediting immediate formative feedback; promoting dialogue; facilitating reflection; and advancing higher order thinking. These findings raised an important question for us: "How best can the role of PARS technology be optimised in enhancing key learning processes for students?" We respond to this question by proposing a set of fundamental, interdependent strategies categorized into three broad areas (preparation; pedagogy; and professional learning) that we believe should be embraced in optimising the role of PARS.

Keywords: student engagement and learning, lectures, clickers

Introduction

As teacher educators located at Edith Cowan University (ECU), Western Australia, we are mindful of the expectations and learning needs of our students, many of whom can be described as 'digital natives' (Prensky, 2004) or 'Generation Y' (Bank, 2002). They have grown up with technology and integrated it into every aspect of their lives. They are often

visually-oriented learners who prefer to use technology for learning than traditional print based media (Bank, 2002). These students regularly fail to engage in learning when attending large classes where an auditory/verbal style of lecture delivery is predominantly used. In Western Australia and the broader Australian context it is apparent that the inclusion of technology as a learning and teaching tool in pre-service teacher education courses is paramount (Lane, 2008).

With this context in mind, we looked at technologies that would not only enhance the engagement and learning of our education students in large lecture settings, but also offer them additional ideas on how to engage their own students in learning. We wanted to model for our pre-service teachers innovative ways of using a new technology to enhance the learning experience. Many pre-service teachers lack confidence in using technology and can benefit by seeing positive role models interacting with technology (Comber, Colley, Hargreaves & Dom, 1997; Lane, 2005). Consequently, we decided to trial a Personal Audience Response System (PARS).

A common version of PARS is handheld keypads (ResponseCard® SDK) which permit students, through radio frequency and infrared technology, to give instant individual responses to questions and surveys posed in lectures and tutorials. Through a software program (TurningPoint 2008®) the data are automatically analysed and available for display to the students. The literature on PARS reflects a wide range of different terms such as audience response systems, electronic response systems, classroom response systems, and most commonly 'clickers'. The technology is widely used in higher education in North America, and increasingly so in Australian universities.

Most literature on PARS relates to the physical, biological, medical and computer sciences. With the exception of psychology, the humanities do not feature much. There appears to be no discernable studies on the application of PARS in teacher education. Despite the literature often making reference to the effectiveness of the technology being dependent on the pedagogy employed (for example, Draper, Cargill & Cutts, 2002), little consideration is given to the *relationship* between the pedagogy, the technology, and student learning processes. There is a tendency to offer best practice 'tips' for implementing PARS in the classroom, usually with a technical emphasis (Caldwell, 2007; Martyn, 2007).

Motivated by the absence of PARS studies in teacher education, and interested in interrogating our own practice, we conducted an evaluation which compelling indicated that this technology enhanced student engagement and learning. The observations we made from the literature, in conjunction with our evaluation findings, raised an important question for us: "How best can the role of PARS technology be optimised in enhancing key learning processes for students?" We endeavour to answer this question in our paper. In doing so, we briefly describe our PARS Project and proceed with a short discussion on the learning processes that the technology appeared to enhance. We consolidate our insights by proposing a set of fundamental, interactive strategies categorized into three broad areas (preparation; pedagogy; and professional learning) that we believe should be embraced in optimising the role of PARS.

Our PARS project

In semester 2, 2008 we applied the PARS technology extensively in our lectures at ECU with three cohorts of undergraduate and postgraduate education students ($n = \pm 300$). We used the technology predominantly to develop *mastery goals* (learning outcome oriented) rather than meeting *performance goals* (gathering data or recording scores) (Fies & Marshall, 2008). More specifically, we applied PARS to:

- facilitate student self-reflection and self-assessment
- determine levels and quality of understanding
- scaffold conceptual understanding
- challenge thinking
- initiate discussions
- encourage students to use PARS
- conduct occasional surveys
- evaluate the effectiveness of the technology.

This was a new technology for us and our students. Consequently we conducted an evaluation with the students to ascertain their perspective on the extent to which this technology enhanced their engagement and learning in these lectures and how (if at all) it did so. The evaluation constituted both quantitative and qualitative data collection. Using the technology in the lectures, substantive survey-based quantitative data were gathered ($n = \pm 290$). The survey consisted of twenty two statements requiring a response to a five-point Likert scale. They focused predominantly on determining the extent to which students believed that the technology supported their learning, and in what ways it did so (e.g. giving an opportunity to immediately assess levels of knowledge and understanding; anonymity in responding to questions; challenging thinking about how to apply knowledge; giving an opportunity to explain and defend responses to fellow students). Qualitative data were consolidated through focus group interviews ($n = \pm 167$) held during tutorials. The focus groups concentrated on exploring the nature of the learning experience for the students and how the PARS technology contributed to this experience. This data were analysed by applying Miles & Huberman's (1994) qualitative analysis process of data reduction, data display, and conclusion drawing. With reference to the evaluation findings and literature on PARS, we applied action research methodology (Hui & Grossman, 2008) to reflect, review, and improve our pedagogy.

It is beyond the scope of this paper to report on the details of the evaluation findings. Suffice to say, the survey indicated that in terms of a consolidated 'agree/strongly agree' 76% of all students surveyed believed that the use of the keypads in the lectures enhanced their engagement and learning. This included findings such as 67% of students agreeing that the technology helped them improve their knowledge; 65% agreeing that the technology supported the development of their critical thinking skills; and 79% agreeing that it gave them the opportunity to express their thoughts and views. In summary, a synthesis of the survey and focus group interviews data showed overwhelmingly that students considered the main benefits to be *interactive learning* (active involvement, discussions, sharing ideas, engaging, fun); *the promotion of higher order thinking skills* (critical and reflective thinking, developing deeper understanding and meaning); *immediacy of feedback* (able to compare with peers' views; monitor own understanding); and *anonymity in contributing responses* (no peer judgement, non-threatening, allowing for more 'risk-taking'). Key problem areas reflected included *technical challenges* (not sure how to use the keypads, and if response was registered); *time consuming* (concerned about lecture content not being fully covered); and *authenticity of responses* (some students not responding honestly).

Our evaluation findings generally concur with those reported in the literature, in particular, the benefits, disadvantages, and 'cautionary tales' of the technology (Caldwell, 2007; Cutts, Kennedy, Mitchell, & Draper, 2004; Fies & Marshall, 2006; Hanson, 2007; Martyn, 2007; MacGeorge et al, 2008; O' Donoghue and O'Steen, 2007; Sharma, Khachan, Chan & O'Byrne, 2005; Stowell & Nelson, 2007).

PARS and student learning

In considering 'conclusion drawing' as part of our qualitative data analysis (Miles & Huberman, 1994), we identified four discernable learning processes that the application of the technology appeared to enhance for our students in the context of their learning and the lecture environment. We briefly discuss each of these and include a few student quotes from the focus group interviews to illustrate the role of PARS in enhancing their learning.

Expediting immediate formative feedback

Well-formed questions illicit immediate formative feedback to the learner, prompt discussion, allow self-monitoring and tell the teacher how well the class understands an issue. Interactivity is encouraged for both the learner and lecturer when the subsequent teaching, based on student answers to questions, is varied in response to the learner's needs. We identified the potential of PARS technology in assisting our understanding of students' prior knowledge, our immediate response to general misconceptions, and the consequent adjustment to the pace and conceptual level of the lecture. Student quotes illustrating this learning process included:

"Honest, instantaneous feedback, free from the judgement of peers."
"You can check your answers against everyone else's."
"Allows me to cement or correct understanding."
"I liked being able to see if my thoughts and attitudes were similar to my peers."

Promoting dialogue

Laurillard (cited in Cutts, Kennedy, Mitchell, & Draper, 2004) sees dialogue as a crucial component of learning and states that it is almost impossible to achieve in lectures. Impediments to dialogue in lectures can be overcome by adjusting activities in lectures, using group response systems and using extensions to PARS. One advantage of the interactive nature of PARS technology is in the prompting of mental processing in each learner's mind, when they are forced to consider a question and decide on an answer. Careful intent and thought behind the design of the questions assisted in critically extending students thinking.

We employed several strategies to promote dialogue and encourage collaborative learning. They included having students share their answers with partner/s, predict majority answers, discuss their rationale for answer choices, and giving students opportunities to reconsider original answers. 'Generation Y' students like to learn in social contexts, with and from each other and clearly students found the interactive learning beneficial:

"The ability to see what other opinions are and compare them with your own."
"Learning to be critical towards views that might be one's own or someone else's."
"Stimulates opinion based group discussion."
"Helped me retain information and learn from my peers."

Facilitating reflection

The relationship between reflection and learning is addressed extensively in the education literature. Hendricks (2009) identifies particular conceptual reflective processes such as autobiographical, collaborative, internally directed and externally directed reflection, all of which can be addressed using PARS technology to enhance student learning. As a reflective tool, it allows students to not only reflect on their own beliefs, but to be involved in collaborative reflection, where self understanding is enhanced by sharing ideas and understanding the perspectives of others. The opportunity for individual reflection, group reflection, and then reflection on the group thinking, afforded by the immediacy of the feedback from the PARS technology, enhanced opportunities for student learning. The following quotes illustrate this:

> *"Allows you to reflect on your own understanding and beliefs."*
> *"I liked being able to see if my thoughts and attitudes were similar to my peers."*

Advancing higher order thinking

Higher order thinking skills (critical and reflective thinking) were considered by students to be one of the main benefits of using PARS in lectures. Jonassen (cited in Sheffield, 2007, p.3) refers to technologies such as PARS as mindtools which "function as intellectual partners with the learner in order to engage and facilitate critical thinking and higher order learning". As our intention was to engage students' higher order thinking skills, we built questions which would encourage students to analyse, evaluate and create (Anderson & Krathwohl, 2001). Nuances were built into questions, which encouraged students, first of all, to deconstruct and interrogate (analyse) the meaning of the questions. Sometimes students were asked to discuss their responses to a question within groups and then deliver a group response or, if answering individually, students were asked why they had answered in a particular way. Either approach allowed students to make a judgment, justify that judgment and then check their understanding against the decisions of the whole group (evaluate). By constructing their own answers, based upon previously-gained conceptual knowledge and the ideas of their peers, students were able to develop new ways of looking at things (create).

The following student quotes reflect this learning process:

> *"Encourages higher order thinking because there is a requirement to really think about the questions."*
> *"Makes you actively consider lecture content."*
> *"Makes me think about the topic in more depth."*
> *"...it was good to respond to the questions as it made me think about and understand the topic better."*

Optimising the role of PARS

Arguably, best practice lecture pedagogies can achieve most of the learning processes identified in our study without PARS technology. It is clear though that this technology is a potentially powerful 'tool' to enhance student engagement and learning. It can add considerable value to the learning experience that is simply not possible even when best practice is applied. The obvious example is the technology's potency in providing immediate consolidated feedback. There is a caveat to all of this, however. Fies & Marshall (2008, p.489) capture it when they point out that "it is absolutely possible to adopt a CRS (PARS) without changing classroom practice. In other words, the tool does not necessarily drive

pedagogical change". The danger lies in adopting an 'add-on' rather than 'add-in' approach to embracing the technology. This is what prompted our question on how best to optimise the role of PARS in enhancing key learning processes for students in large lecture environments. In reflecting on this question, we summarize below a range of fundamental, interdependent strategies that we identified though our action research methodology to be imperative in optimising the role of PARS. We have categorised them into three broad areas, namely: preparation; pedagogy; and professional learning.

Preparation

We suggest that the following four strategies are applied in preparing the application of the technology:

- Be clear about the **purpose** of applying the technology. Is it primarily to develop *mastery goals* or meeting *performance goals*, or both (Fies & Marshall, 2008)? How is the technology intended to enhance the learning experience and achieve learning outcomes? Addressing these questions will help to clarify the rationale and purpose of using the technology.
- Be sure that there is **basic support** for the technology. This includes 'champions' of the potential benefits of the technology, administrative (assistance in managing the distribution and collection of the keypads), technical (how to prepare the lecture materials using the software, how to apply the technology in lectures, how to store, retrieve, and manipulate the data), and financial (what funds can be accessed to purchase the technology?).
- Establish **a team of colleagues** who are prepared to take some risks in applying the technology, and are prepared to reflect and improve upon their practice in an open and collaborative way. Working within a learning community will help develop confidence and competence. This is essential. Students, the majority of whom are likely to be competent with technologies themselves, will make tacit judgements about lecturer expertise. Modeling proficiency is certainly important in encouraging pre-service teachers to integrate new technologies in their classrooms.
- From the outset, **explain** clearly to the students the mechanics of the technology, and the intended learning benefits of its application. This will establish a platform for formative feedback from the students on their experience of the technology, thus offering the lecturer opportunities to minimize technical problems, maximize its pedagogical impact, and support students in developing meta-cognitive skills in understanding and improving their learning.

Pedagogy

This refers to specific teaching methods and skills that we believe need special attention in order to optimise the role of PARS. We advocate that they should be fundamentally aligned with a "learner-centred and learning outcomes approach" rather than a "teacher-centred and admin concerns approach" (Fies & Marshall, 2008).

Careful construction of questions.

Questioning is probably the most critical pedagogical aspect of applying PARS effectively. It is fundamental to expediting immediate formative feedback, promoting dialogue, facilitating reflection, and advancing higher order thinking. We discovered, like Caldwell (2007), that the question design, regardless of the nature of the answers required, should have a structure and content that reflect specific learning goals. This requires careful consideration of both the nature of the questions and the pedagogy used to enhance student engagement and thinking.

Content-focused questions that simply seek factual responses are sure to disengage students. We recommend that to help in clarifying the purpose of a question, a simple matrix be designed which includes on one axis the kinds of questions that can be constructed according to the PARS technology (e.g. Likert scale; closed-ended; choice; etc.), and on the other a list of learning processes/outcomes (e.g. self-reflection; self-assessment; higher order thinking; etc.). The matrix can then be completed according to the relevance of the question against the learning process/outcome.

Data analysis

The immediacy of providing students with an analysis of their collective responses is clearly a defining feature of the PARS technology. The challenge, of course, is how pedagogically to use this feature so that it enhances learning. This pre-supposes clarity of purpose and careful construction of questions that elicit the data. We suggest that whatever data are generated, it is principally thought-provoking and presented to students for their analysis and interpretation. This implies a limited number of 'rich' questions rather than a large suite of superficial ones which do not substantially extend learning. We have discerned three kinds of data.

Firstly, there is 'before and after' bench-marking data. They are generated from questions asking students to reflect on their current knowledge and understanding of a particular topic or concept (prior knowledge), and to do likewise after a learning experience (gained knowledge), such as a lecture. Having students monitor their learning progress, and compare it with the class, is good practice. It also permits the lecturer to determine formatively how students perceive their progress, and to make any learning and teaching modifications if warranted.

Secondly, there is what we call 'quality assurance' data, which are generated from finely tuned questions designed to assess the calibre of students' understanding and application of complex concepts and principles. Where such data presents evidence of confusion, it is very useful to engage students collaboratively in determining the nature of the misunderstanding and then for the lecturer to review the concept. Re-polling the question or preferably presenting a different one that targets the same concept is advisable.

Thirdly, there is 'higher order thinking' data produced primarily by questions which challenge students' philosophy, values, attitudes, and opinions. Such data are likely to reflect and engender 'cognitive dissonance', and present much opportunity for dialogue and creative problem-solving. The PARS software has the capacity to analyse data according to demographic information (data-slicing). For example, data can be 'split' in terms of gender profile. This function has the potential to confront students with powerful information that contests deeply held beliefs and values.

Contingent teaching

Contingent teaching refers to "designing sessions not as fixed scripts but to zero in on using diagnostic questions on the points that the particular audience most needs on this occasion" (Draper & Brown, 2004, p. 81). This is called 'just-in-time-teaching'. Immediate performance feedback promotes deeper processing of the material by guiding the cognitive activities necessary to learn effectively (Butler & Winne, 1995) and allowing opportunities to respond to questions and receive immediate feedback gives students control over their own learning, which, in turn, facilitates comprehension (Locke & Latham, 1990).

PARS can facilitate contingent teaching by allowing levels of student understanding and conceptual attainment to be gauged instantly through displayed student responses to questions. Discussion can be initiated around the responses, expediting immediate formative feedback, or a new set of questions can be created, at the students' point of need, to stimulate higher order thinking. The software offers a function ('on-the-fly slide') which allows for the quick construction of an interactive slide that is responsive to a teachable moment.

Small group discussions
Interactive engagement through peer discussion is considered to be a pedagogical approach with considerable potential in enhancing learning (Draper & Brown, 2004). Fies and Marshall (2006) report that recent reviews point to the technology being overwhelmingly used to collect individual rather than group responses. While this has advantages in relation to individual accountability and monitoring learning progress, it does not maximize the prospect of students learning with and from one another. Caldwell (2007) cites research conducted by Nichol and Boyle which indicates students having a preference for small group discussions as opposed to class-wide discussions facilitated by the teacher. Our experience and student feedback concur with this finding. Within our lectures, small groups of three were asked to discuss their responses to certain questions and justify their joint response, using one keypad response per group of three, promoting dialogue and higher order thinking. Students were also asked to use a 'prediction' strategy, briefly discussing their predictions in terms of a question posed. We would thus recommend that the pedagogical design of applying the technology includes *both* individual and small group responses, depending on the purpose of the technology in the first instance.

Professional learning
An important component of our project was the collegial support we shared and our openness to learning from one another. If the introduction of PARS is nurtured as a catalyst for reflective, critical and robust interrogation of pedagogy, the technology can contribute considerably to improving the way in which lectures (and other learning and teaching processes) are designed and delivered. Action research allowed us to demonstrate the benefits of using PARS as a pedagogical tool and reflect on the best way to optimise such use of technology. We strongly recommend that the preparation strategy of establishing a team of colleagues is constituted as a professional learning community which not only focuses on collegial support but also embraces the challenge of improving practice. We contend that if all else 'failed' in our PARS project, we triumphed in terms of professional growth.

Concluding comments

We recognize that a limitation of our study was not being able to ascertain in any substantive way the difference the technology made in achieving learning *outcomes*. This is in part due to the complex recursive relationship between the two – the technology is only as effective as the pedagogy which it serves and is served by. Determining *linear causality* in learning and teaching is over-simplistic and potentially misleading. Although we noted a significantly higher than normal summative outcomes (the exam) with our largest first year cohort of students, we have no evidence that it was associated with the technology or not. Investigating this is the topic of further research, and certainly an area which others advocate for (Fies & Marshall, 2006; Martyn, 2007).

The evaluation indicated that the technology should be used sparingly, strategically, and competently. Over-use can undoubtedly be counter-productive. We have a strong conviction

that any inclusion of a new technology in higher education ought to be very thoughtfully and robustly incorporated in learning and teaching processes so that it is sustained as a means to an end rather than becoming an end in itself. We are mindful of O'Donoghue & O'Steen (2007, p. 772) warning educators against being seduced by the technology ("technology for technology's sake"; becoming "distracted and entranced by the tools"). Our hope is that we maintain a constant, critical eye on how best to guard against new technologies being naively abused as the panacea of all matters associated with learning and teaching, while simultaneously optimizing their oft under-valued role in enhancing student learning.

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