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## TITLE

THE UTILITY AND IMPACT OF INFORMATION COMMUNICATION TECHNOLOGY (ICT) FOR  
PRE-REGISTRATION NURSE EDUCATION: A NARRATIVE SYNTHESIS SYSTEMATIC REVIEW

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## CONFLICT OF INTERESTS

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## ABSTRACT

**Objectives:** To evaluate and summarise the utility and impact of information communication technology (ICT) in enhancing student performance and the learning environment in pre-registration nursing.

**Design:** A systematic review of empirical research across a range of themes in ICT health-related education.

**Data Sources:** Science Direct, Cinahl, AMED, MEDLINE, PubMed, ASSIA, OVID and OVID SP (2008 – 2014). Further date parameters were imposed by theme.

**Review methods:** Evidence was reviewed by narrative synthesis, adopting Caldwell's appraisal framework and CASP for qualitative methods. Selection and inclusion was grounded in the PICOS structure, with language requirements (English), and further parameters were guided by theme appropriateness.

**Results:** Fifty-one studies were selected for review across six domains: reusable learning objects, media, audience response systems, e-portfolios, computer-based assessment and faculty adoption of e-learning. Educational ICT was found to be non-inferior to traditional teaching, while offering benefits to teaching and learning efficiency. Where support is in place, ICT improves the learning environment for staff and students, but human and environmental barriers need to be addressed.

**Conclusion:** This review illuminates more advantages for ICT in nurse training than previously. The key advantage of flexibility is supported, though with little evidence for effect on depth of learning.

## INTRODUCTION

Information communication technology (ICT) is being introduced globally into nurse training with an accompanying demand for computer literacy for both students and educators (Button et al. 2014). The United Kingdom's (UK) standards for pre-registration nurse education emphasise the need for newly trained nurses to have skills in education, leadership, research and communication as well as the expected clinical practitioner skills of their predecessors (NMC 2010). The standards also emphasise the need for 'future proofing' the profession to ensure that practice and knowledge remains up to date. This means practitioners having the skills to access and make use of information systems and the increasing technology in the clinical area.

While and Dewsbury (2011) argue that nurses need to be competent in informatics in their clinical practice. They suggest that the nursing workforce needs to have communication ICT skills in order to be the electronic systems managers which the profession increasingly requires. It is therefore important that nurse training includes ICT skills as an integral part of the learning experience as well as the core skills necessary to access modern learning resources.

However, ICT presents a challenge to educators in the transfer from what While and Dewsbury call the 'face-to-face to the information age' (p. 1303). Button et al. (2014) identify a range of advantages to including ICT in nurse education but also find barriers to its adoption:

### Advantages:

Flexibility of learning	self-paced and rapid access to information
Depth of learning	greater engagement and deeper learning

### Disadvantages:

Technical problems	for students and staff and reliance on technical staff to problem-solve
Staff development	educators may lack the skills to develop and deliver ICT learning
Staff time	teaching staff do not have time to develop skills and there may be poor recognition of staff time needed to develop and respond to ICT resource production
Student skills	students lack ICT literacy. Educators need to provide ICT training.

### Background

Nurse educators need to ensure nurses have ICT literacy, and the adoption of e-learning and classroom based information technology is a necessary step towards this. ICT also facilitates effective clinical skills acquisition in a safe environment and enhances face-to-face learning, asynchronous communication with staff and study groups, and contributes to in-classroom interaction and record keeping (Bloomfield and Jones 2013, Feng et al. 2013). This review will therefore focus on both the effectiveness of specific ICT methods and the implementation of those methods as there is a clear 'trade –off' of effectiveness and practical adoption of ICT in the classroom.

## THE REVIEW

### Aims

The aims of this review are to determine which methods of ICT delivery have utility and impact in delivering effective pre-registration nursing education. Specifically, the objectives are to identify key forms of ICT available to academic nurse educators and to examine the efficacy of these resources, including barriers and facilitators of their use.

The review question is:

What electronic learning resources could academic nurse educators adopt to enhance the delivery and efficacy of pre-registration nurse education?

### Design

We conducted a systematic review using narrative synthesis due to the high heterogeneity of included studies, as guided by the Guidance on the Conduct of Narrative Synthesis (Popay et al (2006). This approach facilitates synthesis of a range of methodologies and study designs, and allows a focus on a wide range of ICT methods and applications. The review was approached in 4 stages: initial topic mapping and strand identification, question formation and inclusion processes, data extraction and appraisal, synthesis of strands and overall findings.

### Search strategy

Due to the scope of the subject, the initial scoping review and mapping (Popay et al. 2006) was performed to identify distinct topic areas which identified seven distinct areas applicable to our enquiry:

1. online resources: Reusable learning objects (RLOs)/open education resources (OERs)
2. podcasts and social media
3. computer based assessment
4. audience response systems (ARS)
5. e-portfolios
6. faculty adoption of e-learning
7. simulation

Electronic simulation in health care training was considered a specific practitioner training technology, separate from campus based learning, and therefore was excluded from this review. A team approach was adopted to conduct parallel searches for each topic area. Each team member conducted the initial search using the same inclusion criteria and parameters. Following this stage, team members imposed further search parameters according to the topic area. Figure 1 summarises the search protocols and combined results. A PICOS structure was used to guide inclusion criteria:

- Population: evidence is applicable to a pre-registration nursing population within the UK

- Intervention: interventions focus on testing use of electronic learning/teaching resources
- Comparisons: face-to-face teaching, conventional classroom teaching delivery methods
- Outcome: measured outcomes relate to effectiveness of use of electronic resources
- Study design: full range of quantitative and qualitative primary methodologies

Parameters were widened where topic-specific evidence proved to be limited or where the topic necessitated different methodologies. Date, context and quality parameters were narrowed where topics related to newer technologies or where strong evidence was abundant. Each topic strand was searched independently, firstly, by general eligibility and secondly by topic-specific search terms and limits. Final inclusion was adjudicated by the lead researcher (LW). Included articles were exchanged between search threads where relevant evidence was found. This resulted in three transferred papers.

Overall eligibility was restricted to 2008-2014, higher education (HE) context, Western-equivalent education system and English language. Further specific limits were imposed in each topic area. The following databases were searched: Science Direct, CINAHL, Medline, ASSIA, OVID and OVID SP.

#### Study selection and quality appraisal

Selection of included studies was guided initially by Caldwell's appraisal framework (Caldwell et al. 2005). Final inclusion of studies was based on methodological quality using the modified version of the Critical Appraisal Skills Programme (CASP) for qualitative research (CASP UK, 2006). The quality assessment was conducted independently by the five authors.

## RESULTS

Tables 1 - 5 list the included studies by topic area. A total of 51 articles were included in the review. Narrative synthesis was conducted independently by authors by pre-selected themes (stage one mapping exercise), followed by a team approach to overall synthesis.

#### Online resources

Two comparison studies found significantly improved clinical or knowledge skills for students accessing online material blended with traditional teaching (Lancaster et al. 2012, Holland et al. 2013). However, these studies compare enhanced material with standard lectures and so findings merely demonstrate that teaching, enhanced with online material, improved students' learning and transfer to practice. Lack of control group does not allow comparison between online and traditional learning.

Aleman et al.'s (2011) study and Segal et al.'s (2013) comparison studies both compared computer-assisted and traditional learning, showing no significant lasting difference between groups. However, Segal et al. (2013) found time spent online was shorter than the academic hours required for traditional teaching, with no significant reduction in learning achievement. Griff & Matter's (2013) study, comparing a responsive online self-testing program with classroom quizzes across six institutions, also found no significant difference between the two approaches). However, the large

variation between institutions suggests the teaching environment was more important than teaching medium in this study design.

Keefe and Wharrad (2012) did find significant overall improvement for e-learning as measured by MCQs, as did DeBate et al. (2014) in a randomised trial in comparing an interactive e-learning program against a 'flat-text' e-learning program. This study found significant improvements in all application based skills, but no differences in general knowledge or patient empathy.

A similar study (Mehrdad et al. 2011) compared face-to-face lectures with asynchronous online learning, with no difference between learning methods, but significantly higher engagement online than in the classroom. Deep learning was superior in the online condition, and application factors significantly higher for classroom learning.

Lu and Lemonde (2013) and Worm (2013) compared surface and deep learning, finding no significant difference between groups. However, Lu and Lemonde found low performers gained higher scores in the face-to-face group, while high performers did better in the online group. In contrast to Aleman et al.'s (2011) study, Worm found students spent more time online than in the classroom, suggesting that face-to-face teaching is more time efficient for students.

A sub-theme of online resources was 'presence' and voluntariness. Junco et al.'s (2013) study compared mandatory versus voluntary engagement, finding no difference in grades or engagement. Similarly, Zvanut et al. (2011) incorporated 'presence' into their study, finding that voluntariness increased perceived barriers such as access difficulty, but being seen online (presence) was influential in mandatory learning. 'Presence' was also found to be associated with significantly higher satisfaction and group interaction among graduate nurses studying online (Mayne and Wu 2011). Lin's (2013) RCT showed no significant difference between discussion board and online individual learners in skills application, but there was significant higher knowledge, superiority in error-detection and overall critical thinking skills among the discussion board group.

#### Podcasts and social media

Learning time was a factor in Abate's (2013) comparison study, testing unsegmented podcasts, segmented podcasts and face-to-face teaching. Students using segmented podcasts with topic breaks recorded higher scores on knowledge gain and application/critical thinking than the other groups. However, while learning time was shorter for podcasts, 95% of podcast students listened to the podcasts more than once, increasing learning time to more than the face to face group.

Engagement was a factor for Kazlauskas and Robinson (2012) who surveyed business and nursing students on use of podcasts and divided them into 'listeners' or 'non-listeners'. The only significant difference was that non-listeners tended to be engaged in outside employment. They suggest that podcasts do not bring more flexibility to students who are time poor. Similarity of podcast usage between these diverse student cohorts suggests that preference for use may be an individual choice rather than a factor associated with 'type' of student.

Engagement was also a factor for Gipson and Richards (2011) who compared pre-class lecture notes with pre-class podcasts. No difference was found in post-test performance but significantly fewer

students used the podcasts due to time constraints and technical difficulties. However, Junco et al. (2013) found significant increase in grades and engagement for students allocated to Twitter compared to students allocated to an online discussion forum (Ning).

#### Computer-based assessment

Included studies examining online assessment methods all compared online assessment with traditional assessment methods. Student preference for online assessment was positive (Deutsch et al. 2011; Caudle et al 2012; Chen and Chuang 2012; Nutan and Demps 2014), while effectiveness of computer-based assessment was found to be convenient and time saving (Deutsch et al. 2012; Nutan and Demps 2014), and accommodated large numbers of students (Hutton et al. 2010).

Hutton et al.'s (2010) comparison of an online assessment tool with observed simulated clinical examination (OSCE) indicated that using computer-simulated assessment was highly predictive of medication dosage skills in practice. The authors suggest that practice assessment may be better for testing technical measurement skills however mathematical skills can be assessed just as well with computer simulation.

Chen and Chuang's (2012) RCT indicated that online testing as an assistance tool is beneficial to student performance, however, the intensity of the effectiveness decreased over time suggesting that users reduced their online activity after initial enthusiasm.

Drawbacks to online assessment were found to be a concern for staff members and students regarding cheating (Deutsch et al. 2012; Caudle et al. 2011), and technical ICT problems (Caudle et al. 2011; Nutan and Demps 2014).

#### Audience response systems

Seventeen papers reported significant improved assessment performance among ARS cohorts. For example, Lantz and Stawiski (2014) demonstrated that clicker use with immediate feedback increased participant engagement and led to significantly higher scores two days after the video lecture than the no-clicker control condition. Shapiro (2009) also found a significant student improvement with ARS-targeted factual test questions.

However, while some papers highlighted the significance of the immediacy of intervention, they also found no replication of results at follow-up stages (Doucet et al. 2009; Liu et al. 2010; Karaman 2011, Tregonning et al. 2012) suggesting that it is most effective for immediate retention of facts (Anderson et al. 2013). Additionally, Shapiro and Gordon (2012) suggest that utilisation of clickers for factual multiple-choice questions appears to enhance memory for delayed factual test questions. Shapiro (2009) also found that student improvement with ARS-targeted factual test questions does not transfer to information not explicitly addressed by the ARS questions.

Other findings indicate that clicker technique is both efficient and cost-effective in conserving teaching time without loss of amount learned (Anderson et al. 2011) and presents a time advantage in comparison with approaches such as quizzes since there is no distribution, collection or marking required (Shapiro 2009; Anderson et al., 2013).



Brady et al. (2013) found ARS did not result in higher meta-cognition in comparison with a low technology polling system, although it did lead to higher performance outcomes. Oswald et al. (2014) examined the effect of increasing the level of social facilitation (peer pressure) on immediate retention of material by identifying individual responders during clicker responses. The results demonstrated significantly higher test performance with individual response identification, concluding that displaying individual responses could enhance objective self-awareness, increase social facilitation and hence performance.

Several studies reported positive student perceptions of learning (Bright et al. 2013; Han & Finkelstein 2013) and increased student participation (Beard et al 2013). ARS may also facilitate engagement within larger class sizes (Doucet et al. 2009; Shapiro 2009; Patterson et al. 2010, Chaudhry 2011; FitzPatrick et al. 2011; Lantz and Stawiski 2014), and highlight areas of learning students do not understand for targeted teaching (Carnaghan et al. 2011).

#### E-portfolios in nurse education

Among the limited studies addressing the use of e-portfolios in nurse education, Garrett et al.'s (2013) mixed methods evaluation of e-portfolios for clinical competence assessment identified that the e-portfolio was convenient, although at times difficult to navigate for both students and tutors. Tutorial staff cited the most benefits, including supporting integration of theory and practice and tracking student progress. Students however raised concerns regarding use e-portfolios for summative clinical assessment in the absence of standardised, transparent processes. The study is limited to a single cohort but offers some insight into the potential benefits and problems of using e-portfolios in assessing competency, and the need for training in this pedagogy among tutors.

Bogossian and Kellet (2010) examined the use of, and access to, e-portfolios among third year student nurses and identified that 88% of students preferred using e-portfolios to traditional paper portfolios. Just over half the sample (57%) believed that e-portfolios better supported the integration of theory and practice, however, 47.5% identified the problem of gaining access to computers whilst in clinical practice and 12% reported negative attitudes from nurse mentors in supporting students to maintain e-portfolios. The findings of this study suggest that whilst e-portfolios may be a useful learning tool there are a number of limitations to their acceptance and therefore quality as an assessment tool for clinical practice.

Pincombe et al.'s (2010) action research pilot with first year midwifery students found almost two thirds preferred e-portfolios. The main benefit cited was being good for keeping track of progress. The main weakness reported was the software and potential for misinterpretation. The authors conclude that both students and facilitators require training and IT support to ensure the e-portfolio is a valid learning tool.

#### Nurse Educators and on-line learning

These studies included qualitative methodologies in order to capture staff perception and experience of ICT teaching delivery. Many of these studies identified ICT support, time for training and time for materials development as perceived requirements to support ICT adoption by faculty members (Sword 2012; Allan et al. 2013; Button et al.2013; Koch 2014).

Terry's (2012) participant observation identified the construction of digital stories as a 'huge learning curve', while Sword's (2012) phenomenological study identified faculty concerns of time, support for training, loss familiar routines, and problems from the asynchronous nature of online teaching, such as lack of immediate feedback and inability to assess students face-to-face.

Attitudes to ICT adoption may influence staff motivation according to Petit-dit-Daniel et al. (2014), while Robinia and Anderson's (2010) cross sectional survey found positive correlation between number of online participations and online teaching efficacy, and between formal training and online teaching efficacy. Participants in their study who were given time for training felt that this was essential to develop online courses.

Koch (2014) reviewed how e-learning transforms the role of the nurse educator, finding challenges included the asynchronous nature of e-learning, whereby the educator needs to anticipate student needs during the construction of the e-learning. Furthermore, learning processes are more individual, requiring frequent personal attention from the educator. Other themes included technical competency, both for trouble-shooting and for effective teaching.

#### EVIDENCE STRENGTH AND RISK OF BIAS

Each search topic and strand required differing types of evidence according to enquiry, and also afforded variable quality of available evidence. Caldwell et al.'s (2005) approach to appraisal of evidence strength enables appraisal which is pertinent to both quantitative and qualitative studies and facilitated flexibility and individual judgement according to the strand of enquiry. The CASP tool for qualitative appraisal ensures risk of bias is reduced in included qualitative studies. However, the majority of the evidence was quantitative but mostly of poor quality. Many studies lacked control groups, and comparison studies had poorly controlled confounds. Notable exceptions adopted quasi-experimental and randomised control designs but few of these extended beyond a single site and so were exposed to confounding variables within the institution.

##### Online resources

None of these studies was considered high quality. Those with robust study designs were either limited to single institutional settings or tested mainly US populations, limiting generalisability.

##### Computer-based assessment

All studies included were at least comparison designs with good sample sizes but only three included pre-registration nursing students. All were single site studies.

##### Audience response systems

The methodological quality of the studies differed but had notable common weaknesses. The randomisation process and allocation concealment were unclear in the randomised control trials (RCTs) and there were limited outcome data, with a number of papers not presenting any baseline characteristics of the groups compared.

### E-portfolios

There was limited evidence available that was relevant to pre-registration nursing students. Only one study used a control comparison condition (Pincombe et al, 2010) and all primary studies were from a single setting. Sample sizes were very small and individually present limited generalisability.

### Faculty adoption of ICT

These studies were highly variable in methodology, including a literature review which at least afforded access to studies in the German language. The experiential evidence was relevant for this strand of enquiry but its inclusion also reflects of the dearth of more robust evidence. The range of evidence however does afford some reliability to the similar findings of lack of staff time, support and training.

## DISCUSSION

This body of evidence largely confirms previous research that electronic teaching media are at least non-inferior to traditional teaching methods applicable to nurse education. It also indicates value-added benefits for adopting ICT in a range of teaching formats which, while not demonstrated to impact directly on student academic performance, allow faculty members to deliver better quality learning. However, faculty members may have development needs to support the delivery of this technology.

### Online resources

Studies which differentiated between basic and complex learning found differences in learning by teaching medium. Lu and Lemonde (2013) and Mehrdad et al. (2011) demonstrated higher performance from online intervention groups. Lu and Lemonde's study suggested more capable students gain more from online (asynchronous) learning, while less able students benefit more from classroom (synchronous) learning.

Comparison of unlimited online availability with traditional classroom teaching inevitably tests asynchronous with synchronous teaching methods as well as delivery style. Traditional learning may be enhanced by video material (Holland et al. 2013), and students can spend less time online with no detrimental effects (Segal et al. 2013). Mehrdad (2011) found students (in a within-group comparison) were better engaged online than in the classroom, and Worm (2013) showed students spent more time using the online resource in the classroom. Measures of effectiveness for online teaching resources consider the burden on teaching and administration staff in cost-effectiveness, however, there may also be a consideration for student time, which increased in several studies comparing online with traditional learning.

### Podcasts and social media

A key feature from these studies was student engagement. Gipson & Richards (2011) and Kazlauskas and Robinson (2012) recorded limited engagement in tasks), identifying barriers to be lack of time and technical problems. Zvanut et al. (2011) and Junco et al. (2013) examined presence online, finding mandatory presence and social approval, rather than voluntariness, to be motivators of engagement. However, when used to enhance discussion, podcasts increased discussion time in class (Gipson & Richards 2011) and online discussion boards improved skills application (Lin 2013).

### Computer-based assessment

Use of online assessment produced similar results to the use of assessment via OSCEs (Hutton et al. 2010) and online testing is beneficial to student results initially, however tends to decrease over time (Chen and Chuang, 2012). Evidence from these studies is tentative at best. Interestingly there were many similarities between the students' and teachers' perceptions of online assessment. Positive themes included; overall convenience, speed of grading, availability of feedback, time saving, environmental friendliness, reduced costs and ease of use. Negative themes included technical glitches, lack of equipment and support, poor internet connection, poor infrastructure and issues around fairness, security and cheating. Teachers also highlighted their own lack of training as a problem.

From the studies reviewed, advantages and disadvantages of replacing traditional with online assessment appear to be evenly balanced, with little evidence of improvement in student performance. The main barriers to universal adoption of online assessment appear to be reliance on IT support and staff training .

### Audience response systems

Studies testing ARS largely confirm they are non-inferior to traditional methods. The majority of studies demonstrate no lasting impact on learning from use of ARS with possible short term improvements in knowledge retention. However, studies demonstrate improved student engagement (Doucet et al. 2009; Patterson et al. 2010; Lantz and Stawiski 2014), and that ARS is popular with students (Barbour 2008). Shapiro (2009) also reported higher attendance in class for interactive groups. Many of the studies tested recall of factual information and Vana et al.'s (2011) well controlled study demonstrated increased comprehension and retention of pharmacological knowledge.

While little evidence supports ARS in delivering lasting deep learning, ARS may have a positive impact on student development (Lantz 2010; Keough 2012) particularly for student engagement and interaction within the classroom (Caldwell 2007; King & Robinson 2009; Chen et al. 2010). The construction of content questions used in ARS may also be beneficial for teaching metacognition and enhancing critical thinking and advanced reasoning skills (DeBourgh 2008; Mareno et al. 2010). Jones et al. 2012), suggest that ARS improves class and peer discussion which impacts positively on metacognition and knowledge transfer.

### E-portfolios

This review highlights a dearth of published research for e-portfolios in nurse education. Studies included here are small scale but suggest that health care students consider e-portfolios to be a useful learning tool. However, problems with access, IT skills and technical support are common themes. It appears that use of e-portfolios would be effective where quality software supports ease of navigation and there is support in practice to protect time and access in the clinical setting. Green et al. (2014) cite evidence that the reflective requirement within an e-portfolio helps bridge the theory practice gap (Joyce 2005; McCready 2006; Karsten 2012), but do not identify whether e-portfolios are better in this than traditional paper portfolios. Given the current trend towards the

integration of online learning resources, this review highlights that nurse education has fallen behind in adopting the e-portfolio, but adds little to the evidence base for their use.

#### Faculty adoption of ICT

The review of faculty use of ICT highlights concerns for staff training and perceived external pressures from HEIs and other external bodies. There are also pedagogical issues concerning the efficacy of synchronous versus asynchronous teaching and learning. These issues indicate that increased individual tutoring and depersonalization of interaction can lead to role conflict and frustration (Robinia and Anderson 2010; Koch 2014). Perceived value of e-learning by nurse educators was also a consistent theme. In three papers, (Sword 2012; Terry 2012; Petit-dit-Dariel et al. 2014) inference is made to staff members' personal motivation as key to engagement of online teaching. This body of evidence suggests that personal motivation may be important, and the valuing of online activities could be a contributing factor to personal motivation.

#### Overall synthesis

The overlapping themes of this review reveal some key aspects of the adoption of ICT for nurse education, in line with Button et al.'s (2014) earlier review of studies up to 2012. Technical problems, access to ICT and in-house support are concerns for both students and faculty. Staff members are also concerned about training and time taken to develop asynchronous learning regimes. However, there may be less concern for student acceptance of ICT as many studies revealed positive attitudes toward online and electronic learning media.

### CONCLUSION

This review has illuminated more advantages for ICT in nurse training than previously. Flexibility of learning offered by asynchronous resources includes ability to review material as well as self-pacing, while in-class resources offer rapid feedback of performance and improve engagement. There is less evidence of deeper learning or sustained information retention, however the studies reviewed did not on the whole explore evidence of deep learning. Those that did, found at least non-inferior results from electronic learning resources.

Overall, this review suggests that ICT offers benefits to nurse education regardless of directly enhancing learning efficacy. Where faculty, practice and administration support is in place, ICT may improve the learning environment for staff and students, but human and environmental barriers need to be addressed, namely staff belief and motivation, and faculty environments to provide time for training and preparation, technical support and efficient systems to enable greater adoption of ICT.

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Table 1. *Online learning resources and use of social media*

Study, design, origin	population	intervention	control	setting
<b>Abate 2013.</b> Randomised comparison pilot study US	Undergraduate nursing students (n=35)	Unsegmented podcast (non-stop) Segmented podcast	Traditional face-to-face lectures	Single HE institution
<b>Aleman et al 2011.</b> Randomised comparison study Spain	Undergraduate nursing students (n=116)	Competitive interactive learning program	Traditional face-to-face clinical skills lectures and demonstrations	
<b>DeBate et al 2014.</b> Randomised trial US	Oral health students (N=317)	Interactive web-based course	Non-interactive online course	18 classes across the US
<b>Gipson &amp; Richards 2011.</b> Quasi-experimental comparison study US	Undergraduate nursing students (n=36)	Video podcasts (ECG interpretation) class discussion	Traditional lectures and pre-lecture notes and class discussion	Single HE institution
<b>Griff &amp; Matter 2013.</b> Comparison study US	Undergraduate anatomy & physiology students (n=587)	'Learnsmart' interactive & responsive program	Quizzes and online textbook	6 HE institutions
<b>Holland et al 2013.</b> Blinded comparison study UK	Undergraduate student nurses (n=322)	Standard lectures & unlimited access to online video demonstrations	Traditional lectures and skills classes	Single HE institution
<b>Junco et al 2013.</b> Controlled quasi experimental US	Undergraduate first year pre-health profession students (n=118)	Assignment to Twitter study groups X required vs voluntary use.	Ning use (self-created social networking)	
<b>Kazlauskas &amp; Robinson 2012.</b> Comparison study Australia	Undergraduate nursing and business students (n=246)	Podcast usage between student cohorts. Listeners vs non-listeners	No control group. Traditional face-to-face lectures and reading	
<b>Keefe &amp; Wharrad 2012.</b> Comparison study UK	Undergraduate nursing students (n=233)	Navigable RLOs (graphical-auditory) in pain management and assessment.	Standard pain education (not described)	Single university teaching hospital: 4 cohorts

<b>Lancaster et al 2012.</b> Comparison study US	Postgraduate nursing students (n=52)	Blended (class & online) inc. Streamed narrated presentation	Traditional lectures/ discussion	Single HE institution
<b>Lin 2013.</b> RCT Taiwan	Undergraduate nursing students (n=98)	Technology based co-operative learning	Technology based individual learning	Single junior college
<b>Lu &amp; Lemonde 2013.</b> Quasi- experimental Canada	Undergraduate health science students (n=82)	Asynchronous online narrated presentation	Traditional lectures	Single HE institution
<b>Mayne &amp; Wu 2011.</b> Comparison pilot US	Post graduate nursing students (n=26)	Online learning resource enhanced with 'social presence' factors	Standard online learning resource	
<b>Mehrdad et al 2011.</b> Cross over comparison Iran	Undergraduate maternal child nurse students (n=32)	e-learning (asynchronous audio- visual, discussion boards)	Traditional lecture (Powerpoint, class discussions)	
<b>Segal et al 2013.</b> Comparison study Israel	Undergraduate nursing students (n=90)	Online learning platform	Traditional lectures	4 nursing programs
<b>Worm 2013.</b> RCT Denmark	Anaesthesiology nurse students (n=63)	e-learning & e-book e-learning & e-case-learning	Case-based classroom learning	Not reported
<b>Zvanut et al 2011.</b> Comparison study Slovenia	Undergraduate nursing students (n=142)	Assignment to optional or mandatory e-learning systems	No control group	Single HE institution

Table 2: *Online assessment*

Study, design, origin	population	intervention	control	setting
<b>Chen &amp; Chuang</b> (2012) Cluster randomised controlled trial Taiwan	Junior college nursing students (n=146)	Online testing	Traditional paper references (n=48) No assistance (n=45)	Single HE institution
<b>Caudle et al</b> (2011) Retrospective comparative US	Pharmacology & Patho-physiology students (n= 102)	Computer based assessments in distance education	Traditional paper based testing	Graduate education programme, distance learning
<b>Deutsch et al</b> (2011) Pre-post comparison Germany	4 <sup>th</sup> year medical students (n=383)	Computer based assessment	Regular written exam	Medical school
<b>Hutton et al</b> (2009) Multi stage quantitative cross-over UK	3 <sup>rd</sup> Year Nursing students (n=50)	Online learning tool	Traditional OSCE	School of nursing at a Single HE institution
<b>Nutan &amp; Demps</b> (2014) US	Physicians, nurses & pharmacists ( n=410	formative assessments of a first year pharmaceutical calculations course	Pen & paper quizzes	Single HE institution

Table 3: *Audience Response Systems*

Study, design, origin	population	intervention	control	setting
<b>Anderson et al (2011)</b> quasi-experimental USA	Undergraduate students (n=48)	Compressed study time using clickers	Non-compressed, full study time	Single HE institution
<b>Anderson et al (2013)</b> quasi-experimental USA	Undergraduate psychology students (n=84)	4 stage laboratory model of in-class clicker study. Experiment 1: Time taken to learn skills. Experiment 2: components of effectiveness	Control group: non-clicker individual study and immediate test scores established for comparison	
<b>Barbour (2008)</b> non-concurrent cohort UK	2 years under-graduate dental students (n= 142)	ARS used over 9 lectures and 1 large tutorial session	traditional lectures and tutorial	
<b>Berry (2009)</b> non-concurrent cohort USA	Undergraduate nursing students (n=65)	An ARS used in classes and remote locations	traditional lecture approach with pre-class quizzes	
<b>Brady et al (2013)</b> quasi-experimental USA	undergraduate psychology students (n= 165)	Clicker group & paddles	Paddles only	
<b>Cain et al (2009)</b> , non-concurrent cohort USA	Undergraduate pharmacy students (n=109)	ARS system during lectures	traditional lecture with oral questions	
<b>Chui et al (2013)</b> quasi-experimental USA	Undergraduate accounting students x2 (n=86)	Clicker- assessed by in-class quizzes	Manual quiz completion	
<b>Doucet et al (2009)</b> non-concurrent cohort Canada	undergraduate veterinary medicine students (n=169)	ARS in a 2 hour case-based discussion lectures	case-based discussion groups	
<b>Elashvili et al (2008)</b> crossover RCT USA	Undergraduate dental students (n=77)	ARS system used with 12 questions throughout lecture	traditional lecture with no questions	
<b>Karaman (2011)</b> quasi-experimental	Undergraduate IT students (n=44)	MCQs by ARS	MCQ verbal response	



Turkey				
<b>Lantz &amp; Stawiski (2014)</b> quasi-experimental USA	Undergraduate psychology programme (n=68)	Video lecture, post-lecture clicker questions	Video lecture without clicker questions	
<b>Liu et al (2010)</b> RCT USA	Undergraduate 2 <sup>nd</sup> year pharmacy course (n=179)	SRS was used in one lecture with five questions	Show of hands	
<b>Mayer et al (2009)</b> quasi-experimental USA	Undergraduate ed. Psychol. students, (n=139)	MCQ discussion and clicker response during lecture	Paper MCQ at end of lecture	
<b>Oswald et al (2014)</b> quasi-experimental USA	Undergraduate psychology students (n=107)	Group feedback of ARS	Individual feedback	
<b>Patterson et al (2010)</b> quasi-experimental USA	Undergraduate nursing students (n=70)	MCQ using the clickers on class	Show of hands	
<b>Shapiro (2009)</b> quasi-experimental USA	Undergraduate psychology students (n=210)	in-class PRS questions on specific test questions	Same test items without PRS	
<b>Shapiro &amp; Gordon (2012)</b> quasi-experimental USA	Undergraduate psychology students (n=331)	Topic questions during lecture supported by clicker questions	Topic questions during lecture not supported by clicker questions	
<b>Tregonning et al (2012)</b> prospective study Australia	5 <sup>th</sup> year medical students (n=170)	ARS in selected lectures	Traditional didactic format of selected lectures	
<b>Vana et al (2011)</b> quasi-experimental USA	Undergraduate nurse students on pharmacology course (n=55)	MCP and ARS for MCQS	Multiple choice power point slides (MCP)	
<b>Welch (2012)</b> quasi-experimental USA	Undergraduate nursing students (n=49)	MCQs in class using clickers	Show of hands	

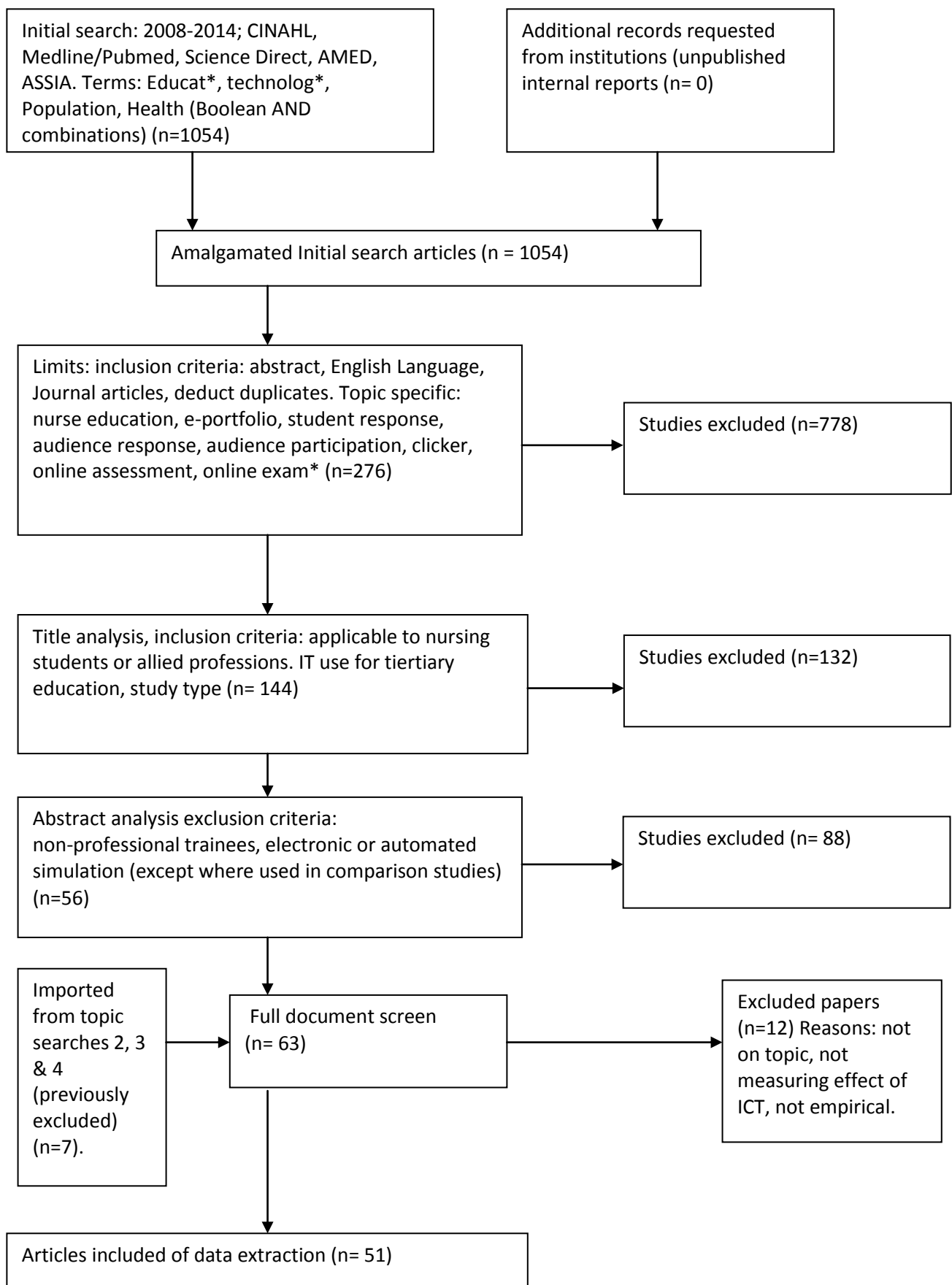


Table 4: *e-portfolios in nurse education*

Study, design, origin	population	intervention	control	setting
<b>Bogossian &amp; Kellett</b> (2010) Cross sectional, Australia	Undergraduate nursing students (third year) n=42 Clinical preceptors n=2	Clinical practice e- portfolio	Paper based portfolio	Single HE setting
<b>Garrett, MacPhee &amp; Jackson</b> (2013) Action research Canada	Baccalaureate nursing students (n=36) Clinical instructors (n=18)		N/A	
<b>Green et al</b> (2014) Lit review UK	Student nurses	N/A	N/A	Multiple HE settings
<b>Pincombe, McKellar, Weise, Grinter &amp; Beresford</b> (2010) Action research Comparison, Australia	First year undergraduate midwifery students (n=18)	Educational e-portfolio	Paper based portfolio	Single HE setting

Table 5: *Nurse educators and on-line learning.*

Study, design, origin	population	intervention	control	setting
<b>Allan H T et al 2013.</b> Three phase, mixed methods study. This paper, phase 2, Focus Groups England	HEI teachers on nursing (n=7), chemistry (n=2) & management (n=3) programmes. (Total n=12)	Staff attitude and views about on-line learning & non-traditional students	Traditional teaching, lecture (PowerPoint, class discussions)	Single HE institution
<b>Button et al 2013.</b> Lit review multiple	Primary research from 2001 - 2012 (n=28)	Issues for students and educators involved with E-learning in pre-registration nursing programs	Traditional teaching, lecture (PowerPoint, class discussions)	
<b>Koch 2014.</b> Literature review English & German	Primary sources published 1990 - 2014 (n=40)	The nurse educator's role in e-learning	Traditional teaching, lecture (PowerPoint, class discussions)	
<b>Petit-dit-Dariel et al 2014.</b> Exploratory descriptive documentary analysis England & France	HEI teachers within English Department of Nursing	Using Bourdieu's theory of practice to understand ICT use amongst nurse educators	Traditional teaching, lecture (PowerPoint, class discussions)	
<b>Robinia and Anderson 2010.</b> Non-randomized cross sectional web based survey. Analysed through descriptive statistics. US.	Recruited 43% (n=140) of their target population, Nurse Educators in HEIs, Michigan, US.	Online teaching efficacy of nurse faculty	Traditional Nursing Programmes - lecture (PowerPoint, class discussions)	HEI nursing faculties across Michigan, US
<b>Sword 2012.</b> Phenomenological study utilizing interviews. US	Nurse faculty (n=20) from 7 HEIs	Transition to online teaching as experienced by nurse educators	Traditional teaching, lecture (PowerPoint, class discussions)	Midwest US HEIs
<b>Terry 2012.</b> Report England	Author's report	Report on using online discussions with a service user to augment his digital story	Traditional classroom visit.	Single HE institution

Figure 1. *Flow diagram: Search protocols & combined results.*

## RESEARCH HIGHLIGHTS

- This review has illuminated more advantages for ICT in nurse training than previous studies.
- ICT offers benefits nurse education regardless of directly enhancing learning efficiency.
- Students show positive attitudes toward online and electronic learning media.
- Faculty, practice and administration support needs to be in place to enable greater adoption of ICT in pre-registration nursing training.

## KEYWORDS

literature review, systematic review, nurse education, information technology, learning resources, online learning, electronic resources.