Mobile Technology for Differentiated Learning and Assessment: A systematic review of empirical studies

Other

Mobile Technology for Differentiated Learning and Assessment: A systematic review of empirical studies

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Abstract

Aim: The aim if the paper is to investigate Mobile Learning (M Learning) and the correlations that may exist between this pedagogy's ability to facilitate differentiated learning and differentiated assessment. The purpose of this review is to establish if M Learning has been used to facilitate differentiated learning and differentiated assessment within education. The review addressed the key aspects of the effectiveness of M Learning by considering if M Learning can lead to greater improvements in learning when compared with traditional learning and assessment?

Methods: A systematic search strategy was conducted during July 2016 in three databases i.e. The Science Direct database, British Education Index (BEI) database and the Education Resources Information Centre (ERIC) database. Studies were deemed eligible if mobile learning was identified as a key term and formed part of an experimental or quasi-experimental design that incorporated a control group in the study. And, the study used quantitative methods to assess the relationship between m learning and improvements in learning. Use of the AMSTAR guidelines were adhered to in order to improve the systematic methodology processes established within this paper.

Conclusion: 17 of the 20 papers that met the eligibility criteria demonstrated a positive impact in relation to improving learning effectiveness. All the studies investigated afforded differentiated learning however the assessments of learning were conducted using methods that were standardised and uniform in nature and therefore not differentiated.

Introduction

Robinson indicates there is a need to transition from an education system that is based upon an industrial model i.e. where students are viewed as empty vessels to be filled with knowledge towards a more responsive and individualised curriculum that recognises the learner's differing skills and diverse needs (Robinson, 2014). Attempts to transcend traditional education practices requires a reconciliation between academic prowess and 'human ecology' i.e. the ability of humans to build relationships with their natural, social and built environments as part of a learning process.

The proliferation of devices that can be used to facilitate M learning has also changed. The Global m-Education Market 2016-2020 indicates that an increase in the market share of Mobile devices of 21% is predicted between 2016 and 2020 is predicated (ReportBuyer, 2015). This coincides with Ipsos-mori that indicates 71% of the United Kingdom (UK) population owns a smart phone and ownership of a tablet has risen to 47% (Ipsos-mori, 2016). Further, accessing the Internet from a smart phone has risen to 69% in the quarter one of 2016 from 34% from quarter three of 2011. The Ipsos-mori report indicates that the most common uses of portable technology such as smart phones and tablets that includes the use of email, Internet browsing and social networking are also reflected in less portable technology such as personal computers (PC's). Therefore, the advantage of mobile learning M learning is *not* always centered on its ability to provide access to existing services or to replace or add to tasks that can already be completed on a non-portable device such as reading text. The tasks we complete in education have not changed but the *functionality* of the tools we use to complete the tasks set have improved learners ability to co-collaborate, co-construct and reflect.

Defining M Learning

Sharples, Taylor and Vavoula (2007) characterised M learning as "learning across multiple contexts, through social and content interactions, using personal electronic devices". In this definition *context* incorporates learning that is a learner initiated and/or teacher initiated; further it may be informal or formal (Sharples, 2009). One of the key challenges with this definition is that it has not been identified at which point, in the learning *and* assessment process, the device acts as the intermediary that facilitates the 'personalization' of technology for human use and enhancing the educational experience (Darling-Hammond, 2014). However, these definitions are narrow and failed to take account of the ecological relationship between humans and technology. M Learning is an individual or collaborative activity devoid of temporal or geographical constraints and can be integrated into the lifestyle of the learner. The flexibility afforded as a result of a lack of temporal or geographical constraints facilitates learning that can involve acquiring information and understanding its relevance using *real world experiences*. This interaction with the real world enables contextualisation of knowledge using software, in the form of mobile applications, or Apps', that are responsive to the user's learning needs and contained on a portable technological device.

Facilitating responsiveness to the learner's needs brings with it the opportunity to facilitate a curriculum that adapts and is individualised to the needs of the learner. The creation of a curriculum that is individualised can be connected with the concept of differentiation where the differing skills and diverse needs of students are accounted for in what has been termed 'instructional differentiation' (Mills et al., 2014). It is M learning's ability to facilitate learning across various contexts along the intersecting axes of geography and time that affords the opportunity for a personalised curriculum. Thus, M learning brings with it the opportunity to allow learners to take ownership of their learning and individualise this according to their needs (Song et al., 2012). However, even this concept has not given rise to the consideration of both instructional differentiation and differentiated assessment. Therefore, the ecology between humans and technology within education and the impact that one may have upon the other in relation to learning and both instructional differentiation and differentiated assessment is an area that requires investigation.

The pedagogical evolution of M Learning

What follows is a critical exploration of the predominant pedagogical changes that have occurred as the relationship between technology and education has evolved since the 1970s. Charting the development of these pedagogical changes is important in order to understand how technology currently influences 'human ecology' i.e. the ability of humans to build relationships with their natural, social and built environments. Additionally, M learning's potential to transform education and to facilitate differentiated learning and assessment can only be viewed in light of technological change and the parallel evolving pedagogies associated with this change. The review is influenced by a critical examination of Crompton's historical review of M Learning and considers the evolving educational pedagogies, as they relate to technology and learning (Crompton, 2013). Further, this examination considers these evolving pedagogies in light of education metaphors that clarify and facilitate comparison with learning behaviors'.

The evolution and changing definitions of M learning can, historically, be linked to the predominant educational pedagogies that have developed in conjunction with popular theories of learning. For instance, Bruner's recognition of discovery learning was superseded, in the 1980s by constructivist learning espoused by Piaget) *and* constructionist learning approaches such as those outlined by Papert and Seymour (Bruner, 1966), (Piaget & Jean, 1957)and (Papert, 1980). The monolgical and dialogical approaches presented by discovery and constructivist learning theories, respectively, are clarified through the Acquisition and Participation Metaphors (Sfard, 1998). In the presence of the acquisition metaphor (AM), learning is synonymous with cognitive education i.e. remembering and understanding. Here, the learner acts as an *individual* vessel where knowledge is placed. The intention is to improve how the mind operates by transmitting information from the teacher to the learner leading to a development of knowledge (Sfard, 1998). For example, Lee's traditional review charts the progress of Computer-Assisted Language Learning (CALL), during the 1970s, and was based upon the behaviourist stimulus response teaching method which included grammar instruction and translation tests (Lee, 2000). This discovery type learning, that encouraged students to deduce concepts in their own mind, was monological in nature and reflective of the AM.

The progression from discovery learning towards dialogical interaction as a method to improve the learner experience was reflective of the constructivist and constructionist learning approaches espoused by Piaget and Papert which was prevalent in the 1980s (Piaget & Jean, 1957)and (Papert & Seymour, 1980). For example, Dossett and Hulvershorn's primary study identified that the mean training time, using computer assisted instruction, was significantly reduced for military personnel who engaged with peer to peer learning than when compared with those who were trained on an individual level (Dossett & Hulvershorn, 1983). This study demonstrated that in the presence of computer technology social interaction proved superior as a learning methodology than when compared with the monological approach identified in Lee's study that related to language acquisition teaching in the 1970s. In this constructivist approach, the acquisition of knowledge occurred when learners actively shared knowledge implicitly and explicitly through social interaction (Lee, 2000). This epistemology did not negate the importance of social interaction, context, prior experience and the learner's experience of education and thus were more reflective of the participation metaphor (Sfard, 1998).

The constructionist approach, that was present in the latter stages of the 1980s, was deemed more efficacious as a method for learners to socially construct knowledge. For instance, Scardamalia and Bereiter indicate that a move towards a 'distribution model' of education in the latter 1980s and early 1990s witnessed the use of computer-supported intentional learning environments (CSILE) (Scardamalia & Bereiter, 1994). Using CSILE learners' were not collectively exposed to the same knowledge but rather each learner knew something of the topic but, *crucially*, did not have access to all of the subject material. The advantage of this constructionist approach to learning over constructivism was that CSILE encouraged the creation of new knowledge as students explored each other's understanding, through discourse. Where the ecological relationship between humans and computers were concerned advances in computers was now facilitating human to human interaction via an electronic medium and could be closely identified with the socio-constructivist theories of learning.

The socio-constructivist theories and associated pedagogy was based upon the axiom that group interactions led to intellectual improvement. This acted in concert with the Problem based learning (PBL) presented by Koschmann and Others that recognized the role of technology in collaborative PBL within medicine (Koschmann & Others, 1994). PBL was akin to the socio-constructivist theories represented in Vygotsgy and evident in the early 1990s (Vygotsky, 1978). Here, the focus was upon reversing the role of the teacher and student. As a result, small groups of students would work critically and creatively to solve problems. PBL shared many similarities with 'expansive learning' that was characterised by Engeström who observed that in order to learn recipients must be allowed to question and influence the application of the knowledge as opposed to being involved in learning that is primarily one directional. Therefore the teacher moves towards a role that is characterised by facilitation (Engeström, 2001).

As interactions between humans could now be facilitated by technology that enabled audio, visual and text communication new metaphors that explained how these connections could be explored in education began to develop. One such metaphor espoused by Brown et al was 'situated cognition', where a learners ability to contextualise their learning and to bridge the chasm between learning and real world practice defined success (Brown et al., 1989). The 'situation cognition' metaphor mirrored the socio-constructivist theories represented in Vygotsgy's work that became a common pedagogical approach of the mid to latter 1990's evidenced by Lintern (Vygotsky, 1978) and (Lintern, 1995). In Lintern's study the premise of situation cognition i.e. learning is ineffective if the learner is removed from the context, was verified through an ethnographic methodological design that considered the effectiveness of flight instruction within the aviation industry. One of the challenges outlined by the study was that integrating technology into pilot training was only achievable within the aviation industry as a result of investment in technology that would facilitate apprenticeship style learning. Thus the challenge, for education, was in repeating a successful transfer of learning by conveniently linking education to technology and avoiding a 'breach between education and practice'.

Viewing the various education metaphors, theories and pedagogies in isolation of each other prevents a fuller understanding of the evolution of M Learning that was first defined by Laouris and Eteokleous (Laouris & Eteokleous, 2005). Indeed it is only when viewing the various tenets of these educational theories *collectively* that the role and importance of M Learning to facilitate differentiated learning and assessment is realised. In fact, as Sfard suggests a "Dictatorship of a single metaphor" or indeed the dictatorship of a single learning theory should be avoided (Sfard, 1998). In order to facilitate a responsive curriculum the role of M learning must be considered in

relationship to the differing learning needs of students that are influenced by the various learning theories, metaphors, learning styles and intelligences that have been identified above.

Gaps in the research

An opportunity to investigate M Learning and the correlations that may exist between this pedagogy's ability to facilitate differentiated learning and differentiated assessment has not been fully explored. Therefore, the influence of the experiential learning model/learning style inventory (Kolb, 2007); learning styles (Honey, P. and Mumford, 1989); Visual, Aural, Read/write, and Kinesthetic (Fleming, N and Mills, 1987); multiple intelligences (Gardner & Hatch, 1989) and more recently the brain hemispheric theories of learning (McGilchrist, 2009) in relation to M learning must be examined.

Materials and Methods

Priori

The purpose of this review is to establish if M Learning has been used to facilitate differentiated learning and differentiated assessment within education. It is anticipated that this review will address the key aspects of the effectiveness of M Learning by considering if M Learning can lead to greater improvements in learning when compared with traditional learning and assessment?

Eligibility

Studies were deemed eligible for review based upon the following criteria;

The use of mobile learning was evident and formed part of an experimental or quasi-experimental design that incorporated a control group in the study. And, the study used quantitative methods to assess the relationship between m learning and improvements in learning. Further, the study considered the role of a variety of learning sources upon student performance that either implicitly or explicitly sought to account for either/and/or differentiation in learning, learning style, multiple intelligences, brain dominance or inclusive learning.

Selection of Studies and risk of bias

Studies were selected using the following protocol. (1) Screening the titles of the articles; (2) viewing the abstract of the relevant article and (3) finally, if the paper had not provided sufficient information the entire article was reviewed.

Use of the AMSTAR guidelines were adhered to in order to improve the methodological processes established within this paper (Shea et al., 2007). nVivo software (version 11.3.1.777) was used to code data that subsequently led to the creation of study characteristics to enable an analysis of the research that was investigated under the following headings, number of participants; age of participants; Device used; Subject Area; Type of Study; Methods; Hypothesis; Statistical Measurement and Result/Outcomes.

Search strategy

A search strategy was conducted during July 2016 in three databases i.e. The Science Direct database, British Education Index (BEI) database and the Education Resources Information Centre (ERIC) database. Table 1 identifies the search strategy that was employed for each database.

Table 1: search strategy employed within the Science Direct Database, British Education Index (BEI) Database and Education Resources Information Centre (ERIC) Databases'

	Science Direct Database	British Education Index (BEI) Database	Education Resources Information Centre (ERIC) Database
BOOLEAN Search Criteria	Mobile learning AND learning style OR multiple intelligence OR differentiation OR inclusive learning OR whole brain	(TI+mobile+learning) +OR+(KW+mobile+learning) +AND+(KW+learning+style) +OR+(KW+multiple+intelligence) +OR+(KW+differentiation) +OR+(KW+inclusive+learning) +OR+ KW whole brain	(TI+mobile+learning) +OR+(KW+mobile+learning) +AND+(KW+learning+style) +OR+(KW+multiple+intelligence) +OR+(KW+differentiation) +OR+(KW+inclusive+learning) +OR+ KW whole brain
Further Search Criteria			
Publication Date	January 2006- July 2016	January 2005- July 2016	January 2005- July 2016
Limit to	Refined to Journals - Computers in Human Behavior. Computers & Education. Learning and Individual Differences.	Academic Journals Full text articles	Academic Journals Full text articles
Total	**18**	**66**	**255**
Selected	**4**	**4**	**12**

Results

Number of participants

From the 20 studies selected within this review nine had been conducted where the researcher had direct involvement with the learners. Five of the studies identified have over 100 participants (Rashid and Asghar, 2016), (Yang, Li and Lu, 2015), (Su and Cheng, 2015), (Wennersten, Quraishy and Velamuri, 2015), (Khazaie and Ketabi, 2011). Of these five studies one had a number of participants that exceeded 1000 i.e. [3327] (Wennersten, Quraishy and Velamuri, 2015). This was largely as a result of the geographically expansive area in which the study took place.

Age of participants

Four of the 20 studies identified provided a mean average age of the participants that aided in identifying at what level the students were being educated at (Rashid and Asghar, 2016), (Yang, Li and Lu, 2015), (Yin et al., 2013) and (Azabdaftari and Mozaheb, 2012). Eight studies provided age ranges for the participants within the studies that indicated those who were using mobile learning were aged between 10 and 22 years of age (Melero, Hernández-Leo and Manatunga, 2015), (Hwang et al., 2013), (Su and Cheng, 2015) (Alemi, Sarab and Lari, 2012), (Fattah, 2015), (Khazaie and Ketabi, 2011), (Zhang, Song and Burston, 2011), (Hung et al., 2012). One study identified the participants as graduates therefore no age could be clearly identified (Garcia-Cabot, de-Marcos and Garcia-Lopez, 2015). The remaining studies included did not clearly state the age of the participants that were involved and this prevented an analysis of the effectiveness of the learning in relation to the age range.

Devices used

All the studies identified used a mobile device in order to facilitate learning. Five of the studies identified used a personal digital assistant (PDA) in order to facilitate learning (Hwang et al., 2013), (Yen Lee, C, Chen, I, & Jung-Chuan Yen, C, 2012), (Yin et al., 2013), (Hung et al., 2012) (Chen, Kao and Sheu, 2005). 10 of the 20 studies identified used a mobile phone or smart phone as part of the teaching process (Melero, Hernández-Leo and Manatunga, 2015), (Rashid and Asghar, 2016), (Yang, Li and Lu, 2015), (Su and Cheng, 2015), (Wennersten, Quraishy and Velamuri, 2015), (Alemi, Sarab and Lari, 2012), (Azabdaftari and Mozaheb, 2012), (Basoglu and Akdemir, 2010), (Fattah, 2015), (Zhang, Song and Burston, 2011). The remaining studies used iPads or laptops with only one using a variety of mobile devices as part of the teaching process (Krivoruchko et al., 2015). One study used a mobile device that was specific to medicine and therefore was not widely available (Wu et al., 2012).

Subject area studied

The studies identified taught a wide variety of educational subjects that included engineering, language, art, ecology and mathematics. Eight studies included a review of the effectiveness of teaching elements of English language or grammar (Wennersten, Quraishy and Velamuri, 2015), (Alemi, Sarab and Lari, 2012), (Azabdaftari and Mozaheb, 2012), (Fattah, 2015), (Khazaie and Ketabi, 2011), (Krivoruchko et al., 2015), (Zhang, Song and Burston, 2011), (Basoglu and Akdemir, 2010). Only one study did not clearly identify which area of study the learners were participating in (Rashid and Asghar, 2016).

Theoretical stance

One of the studies identified indicated that there theoretical stance was non-experimental (Krivoruchko et al., 2015). However, a review of this paper clearly indicates that an experimental approach was adopted. Further, two papers identified their theoretical stance as that of quasi-experimental (Wennersten, Quraishy and Velamuri, 2015), (Khazaie and Ketabi, 2011). The remaining papers were clearly experimental studies and were identified as such by the researchers.

Location of study

From the studies identified non-were located in the United Kingdom or Ireland. The majority of studies i.e. 7, were located in Taiwan (Hwang et al., 2013), (Su and Cheng, 2015), (Yen Lee, C, Chen, I, & Jung-Chuan Yen, C, 2012), (Yin et al., 2013), (Hung et al., 2012), (Wu et al., 2012), (Chen, Kao and Sheu, 2005). The remaining studies were based in Iran (2); Spain (2); Saudi Arabia (2); China (2); India (1); Kazakhstan (1); Turkey (1) and United States of America (USA) (1). (Garcia-Cabot, de-Marcos and Garcia-Lopez, 2015), (Melero, Hernández-Leo and Manatunga, 2015), (Rashid and Asghar, 2016), (Yang, Li and Lu, 2015), (Wennersten, Quraishy and Velamuri, 2015), (Alemi, Sarab and Lari, 2012), (Azabdaftari and Mozaheb, 2012), (Basoglu and Akdemir, 2010), (Fattah, 2015), (Khazaie and Ketabi, 2011), (Kiger, Herro and Prunty, 2012), (Krivoruchko et al., 2015), (Zhang, Song and Burston, 2011). Appendix A represents an outline of the studies investigated.

Methodology

A review of the studies indicates that an experimental approach was adopted by all the researchers to determine the effectiveness of mobile learning upon learning outcomes. In all cases the effectiveness of learning was determined via the application of a post-test assessment process. In three studies learners were assessed prior to the intervention and following the intervention (Rashid and Asghar, 2016), (Wu et al., 2012), (Chen, Kao and Sheu, 2005). Only one study considered the effectiveness of mobile technology taking account of the preferential needs/learning styles of learners by considering the role of graphical, video or text as teaching tools using mobile technology (Yang et al., 2015). The remaining studies applied an experimental approach whereby the experimental group was introduced to mobile learning that incorporated either text or graphical representations of teaching materials. Control groups were given that the same teaching materials however these were not presented on mobile technologies.

Measurement of statistical result

11 of the studies presented used a parametric statistical test to determine the impact of teaching strategies following an intervention (Melero, Hernández-Leo and Manatunga, 2015), (Hwang et al., 2013), (Su and Cheng, 2015), (Yen Lee, C, Chen, I, & Jung-Chuan Yen, C, 2012), (Alemi, Sarab and Lari, 2012), (Azabdaftari and Mozaheb, 2012), (Basoglu and Akdemir, 2010), (Fattah, 2015), (Zhang, Song and Burston, 2011), (Yin et al., 2013), (Hung et al., 2012). Four studies used descriptive statistics to analyse the results which undermined the ability to determine the effectiveness of the interventions that they applied (Wennersten, Quraishy and Velamuri, 2015), (Khazaie and Ketabi, 2011), (Kiger, Herro and Prunty, 2012), (Krivoruchko et al., 2015). Two studies used analysis of variation to determine different factors that may have impacted upon learning other than the use of mobile technologies (Wu et al., 2012), (Chen, Kao and Sheu, 2005). One study used a nonparametric test to determine the effectiveness of the intervention (Garcia-Cabot, de-Marcos and Garcia-Lopez, 2015). Further, one study applied a parametric test to correlate the relationship between the intervention and its effectiveness (Yang, Li and Lu, 2015). One study applied a multiple regression technique, as part of a system of parametric tests, to determine the effectiveness of intervention (Rashid and Asghar, 2016).

Results of the studies

From the studies reviewed 3 of the 20 studies did not prove their hypotheses to be correct (Yang, Li and Lu, 2015), (Yen Lee, C, Chen, I, & Jung-Chuan Yen, C, 2012) and (Alemi, Sarab and Lari, 2012). Of the studies, one had considered the relationship between concentration, the presentation mode of learning materials and academic achievement (Yang et al., 2015). The remaining two studies had considered the effectiveness of M learning when teaching Local Area Network Planning and Implementation and English spelling and grammar (Yen Lee, C, Chen, I, & Jung-Chuan Yen, C, 2012), (Alemi, Sarab and Lari, 2012).

Several studies also considered the role of satisfaction or enjoyment as part of the learning process. Those studies that considered satisfaction or enjoyment among the learners demonstrated that mobile learning had a positive impact upon learner satisfaction (Yang, Li and Lu, 2015) and (Hwang et al., 2013). Results of the studies are outlined in appendix B.

Teaching and assessment methods

A review of all the studies indicates that although the teaching methods varied by either using mobile technology to facilitate access to learning materials or using mobile learning as part of active participation in learning there is no indication that a similar approach was adopted during the post-test assessment procedures. Therefore, whilst text, graphical or video learning materials may have been provided during the learning process there is no information to suggest that the post-test assessment followed a similar pattern of facilitating differentiated learning with differentiated assessment or used mobile learning as part of the assessment process.

Discussion

An analysis of the papers that have been reviewed indicates that mobile learning provides clear benefits in relation to improving the effectiveness of teaching strategies. In the majority of cases mobile learning was used to replicate teaching and learning materials that would have normally been presented via traditional teaching methods that had already been employed. In one instance, mobile learning was used as the sole teaching methodology where differences in the effectiveness of the teaching was determined as a result of the format of the delivery of the teaching materials i.e. where they delivered in a text format, graphically presented or presented via a video. This approach was more reflective of the learning concepts of differentiated teaching associated with the learning style inventory (Kolb, 2007); learning styles (Honey, P. and Mumford, 1989); Visual, Aural, Read/write, and Kinesthetic (Fleming, N and Mills, 1987); multiple intelligences (Gardner & Hatch, 1989). However, the effectiveness of these theories that categorise learners according to preferences and styles of Learning has been criticised by Greenfield for lacking empirical evidence from the field of neuroscience (Henry, 2007).

15 of the 20 studies presented used parametric statistical tests to assess their interventions that gave greater credibility to the results of their research. Of those interventions it is clear from the statistical test used i.e. t-test that the effect of the application of mobile learning *on its own* was considered and not as part of other factors that may have affected the learning process (Melero, Hernández-Leo and Manatunga, 2015), (Hwang et al., 2013), (Su and Cheng, 2015), (Yen Lee, C, Chen, I, & Jung-Chuan Yen, C, 2012), (Alemi, Sarab and Lari, 2012), (Azabdaftari and Mozaheb, 2012), (Basoglu and Akdemir, 2010), (Fattah, 2015), (Zhang, Song and Burston, 2011), (Yin et al., 2013), (Hung et al., 2012).

Within those papers that had considered the role of other factors that may have affected the learning, learner satisfaction, format of the delivery on the mobile learning device as well as concentration levels were considered as aspects of the investigation that would have affected learning outcomes (Rashid and Asghar, 2016) and (Yang, Li and Lu, 2015).

Four of the studies presented had considered the effectiveness of learning using non-parametric statistical tests and had not considered the importance of the relationship between the changes in the results and a statistical significance between the experimental group and the control group. As a result the research, whilst important, could have been more conclusive (Wennersten, Quraishy and Velamuri, 2015), (Khazaie and Ketabi, 2011), (Kiger, Herro and Prunty, 2012), (Krivoruchko et al., 2015).

Conflict-of-interest

I declare that I have no conflict of interests in relation to the research and authorship of this paper.

Strengths and Limitations

I have outlined how this systematic review has met the AMSTAR guidelines, an eleven point checklist tool to measure the quality of systematic reviews, and considered the strengths and limitations of this systematic review below with the associated AMSTAR guidelines in parenthesis (Shea et al., 2007).

This systematic review has adopted a priori design with clear inclusion and exclusion criteria (1). The comprehensive literature review of databases relevant to educational research and technology was established (3); clear links to those studies that were included and excluded (via the use of available URLs) and a clear methodology has been made available (5) (Appendix C); characteristics of included studies were outlined and further the quality of the studies presented were considered when an experimental group formed part of the methodological design process and further included statistical measurement (6, 7). Suggestions' regarding the use of more appropriate methodological approaches has been considered (8). Given that this systematic review has not included a meta-analysis no evidence has been presented to establish homogeneity or heterogeneity among the studies reviewed, neither was publication bias considered (9, 10). I have declared that no conflict of interest is evident in relation to my research and authorship of this paper (11). The paper would benefit from an independent researcher reapplying the research methodology outlined within this systematic review (2). Additionally, the presence of 'grey literature' was not considered in order to ensure that research reviewed provided comprehensive information regarding the methodologies adopted (4).

Limitations and directions of future research

It is clear from the review of the papers reviewed that mobile learning has, among 17 of the 20 papers reviewed, demonstrated a positive impact in relation to improving learning effectiveness. Within the 17 papers it is also evident that mobile technology was used to impart teaching and learning materials that *were not* different from the traditional materials provided to the control groups within the empirical research. Additionally, none of the researchers indicated that the assessment process reflected the differentiated approach adopted during the learning process. All the studies investigated afforded differentiated learning however the assessments of learning were conducted using methods that were standardised and uniform in nature and therefore not differentiated.

Therefore an incongruence exists between the teaching and learning and assessment strategies. I contend that in order for learning to be fully effective differentiated learning must have corresponding differentiated assessment. Thus opportunities for future investigation exist in order to establish if M learning can be used to facilitate both differentiated learning and differentiated assessment in order to take account of the differing skills and diverse needs of students (Mills et al., 2014). Further, as part of this exploration the relationship between enjoyment and learning effectiveness should also be explored.

Appendices

Appendix A: characteristics of studied included within the review

Source	n	Age	Location of Study	Device Used	Subject Area	Type of Study
(Garcia-Cabot et al., 2015)	**30**	Graduate students	Spain	Mobile Device	Web Engineering	Experimental
(Melero et al., 2015)	**76**	Between 14 and 16 years old	Spain	Smart Phone	Art	Experimental
(Rashid & Asghar, 2016)	**761**	20.79 yrs (Mean)	Saudi Arabia	Smart Phone	Unclear	Experimental
(Yang et al., 2015)	**258**	18.96 years (Mean)	China	Smart Phone	Geography, Biology, and Chemistry.	Experimental
(Hwang et al., 2013)	**56**	Aged Between 11 to 12	Taiwan	PDA	Local Culture	Experimental
(Su & Cheng, 2015)	**102**	Aged Between 10–11 years old	Taiwan	Smartphone	Natural Science and Life Technology	Experimental
(Wennersten et al., 2015)	**3,327**	Unclear	India	Mobile Phones	English and Science	Quasi-Experimental
(Yen Lee, C, Chen, I, & Jung-Chuan Yen, C, 2012)	**86**	Unclear	Taiwan	PDA	Local Area Network Planning and Implementation	Experimental
(Alemi et al., 2012)	**45**	Aged between 18- 21.	Iran	Mobile Phones	General English course	Experimental

Source	n	Age	Location of Study	Device Used	Subject Area	Type of Study
(Azabdaftari & Mozaheb, 2012)	**80**	20.5 (Mean)	Iran	Mobile Phones	English literature and Translation at BA level	Experimental
(Basoglu & Akdemir, 2010)	**60**	Unclear	Turkey	Mobile Phones	Undergraduate Compulsory English Preparatory Program	Experimental
(Fattah, 2015)	**30**	20 to 35 years old	Saudi Arabia	Smart Phone	Essay writing	Experimental
(Khazaie & Ketabi, 2011)	**158**	Aged Between 19-23	Iran	Mini-laptop	English recognition and recall	Quasi-Experimental
(Kiger et al., 2012)	**87**	Unclear	USA	iPod touch devices	Mathematics	Experimental
(Krivoruchko et al., 2015)	**82**	Unclear	Kazakhstan	Mobile phones and laptops, net-books. Tablets.	English	Non-Experimental
(Zhang et al., 2011)	**62**	Aged Between 18-22	China	Mobile phones	English	Experimental
(Yin et al., 2013)	**41**	Mean age of 22	Taiwan	PDA's	Computer algorithms	Experimental
(Hung et al., 2012)	**49**	11-12 Years Old	Taiwan	PDA's	Ecology	Experimental
(Wu et al., 2012)	46	Unclear	Taiwan	Mobile device (Specific to Medicine)	Knowledge of the respiratory system	Experimental
(Chen et al., 2005)	**24**	Unclear	Taiwan	PDA	Ecology	Experimental

Appendix B: findings of studies included within the review

Source	Hypothesis	Statistical Measurement	Result	Hypothesis Proved Correct?
(Garcia-Cabot et al., 2015)	"Does mobile learning adaptation impact on learning performance?"	Mann Whitney	The experimental group obtained statistically significantly results i.e. (Mdn = 8.24), U=162.0, p =0.40 compared with the control group i.e. (Mdn = 7.71), U=162.0, p =0.40) indicating the experimental group outperformed the control group.	Yes
(Melero et al., 2015)	Will group work as part of mobile learning lead to improvements in achievement than when compared with non-mobile learning techniques?	T-test	Post test results for those who were part of the experimental group i.e. M learning, indicated statistically significant results than compared with those in the control group (t=2.253, p=<0.05).	Yes
(Rashid & Asghar, 2016)	Does the use of mobile learning, when compared with other techniques, result in greater learning achievement?	Three separate multiple regression	The use of social media, that is incorporated into the learning process as part of mobile learning, had a positive impact upon academic performance (b ¼ 0.14, p < 0.01).	Yes

Source	Hypothesis	Statistical Measurement	Result	Hypothesis Proved Correct?
(Yang et al., 2015)	*Is there* a relationship between mode of learning, interest levels and level of achievement when comparing the use of text, graphical and video content within mobile learning?	Pearson's r	The use of text format in learning is unsuitable for students with high concentration levels similarly video format are unsuitable for those with medium to low concentration levels. Significant yet weak correlations were established between level of interest and concentration (Pearson's r ¼ 0.280, p < 0.01) as well as between concentration and post-test (Pearson's r ¼ 0.206, p < 0.01).	No
(Hwang et al., 2013)	Enquiry-based mobile learning have an effect upon learning achievement and learning attitude?	T-test and ANCOVA	Learning achievement of the experimental group (M learning) was considerably better than that of the control group i.e. F ¼ 4.36 and p 5 0.05.	Yes
(Su & Cheng, 2015)	Will different learning strategies i.e. the use of mobile learning, result in different learning achievements?	T-test and ANCOVA	A large difference was evident in post-examination achievement (p = 0.000) favouring M learning as a more effective teaching strategy.	Yes
(Wennersten et al., 2015)	Will the use of a mixture of subtitled stories, songs, live-action videos, animations and diagrams as a teaching tool in mobile learning result in different learning achievement among learners?	Descriptive statistics	Students who formed part of the experimental group outperformed their counterparts in control schools by an average of 7.92 percentage points.	Yes

Source	Hypothesis	Statistical Measurement	Result	Hypothesis Proved Correct?
(Yen Lee, C, Chen, I, & Jung-Chuan Yen, C, 2012)	Will a difference be evident in the learning achievement of students who use image-based concept mapping compared with text based concept mapping as part of mobile learning?	T-test	No significant differences were found between the teaching methodologies applied and the assessment outcomes ($t = 0.155$, $p = 0.877$). However, there were significant differences between the two groups in relation to the level of understanding ($t = -2.303$, $p = 0.024$) and creating ($t = -2.145$, $p = 0.035$).	No
(Alemi et al., 2012)	"Is there any difference between university students' learning of academic vocabulary items provided via SMS and those learnt by using a dictionary?"	T-test	There was no significant difference between the experimental group and the control group ($t=1.48$, $p= .42$).	No
(Azabdaftari & Mozaheb, 2012)	"Which strategy of vocabulary learning (e.g. flashcards vs. m-learning) is more effective in terms of learning the newly-introduced vocabularies for Iranian EFL learners?"	T-test	The mean calculated for the experimental group was statistically higher than the mean of the control group ($t = 6.99$, $p<0.05$).	Yes
(Basoglu & Akdemir, 2010)	"Is there a difference between the vocabulary learning level of the students using vocabulary learning program in mobile phones before and after the study?"	T-test	The results indicated that there was a statistically significant difference between use of M learning and traditional methods ($t= -7.6$, $p<0.05$).	Yes

Source	Hypothesis	Statistical Measurement	Result	Hypothesis Proved Correct?
(Fattah, 2015)	What is the effectiveness of using 'WhatsApp' i.e. in mobile learning, as a technique to developing students' writing skills?	T-test	The experimental group indicated significant differences in achievement during the assessment process (t= 7.36, P=0.01).	Yes
(Khazaie & Ketabi, 2011)	With the delivery of learning materials via mobile learning that incorporates verbal and visual learning result in differences between participants of learning achievement?	T-test	The use of mobile technology as a learning platform improved learning outcomes for those learning English when audio and visual methods were used together. More importantly, the study revealed that learners with low visual and verbal abilities who were not given text annotation as part of the learning process scored lower than those who received both visual, verbal and textual learning cues during assessment (p=0.000).	Yes
(Kiger et al., 2012)	Does the use of mobile learning result in greater learning achievement than compared with traditional methods?	Descriptive statistics	The mean results for M learning students indicated that more items were answered correctly on the post intervention multiplication test (M = 54.5, SD = 14.8) than the Comparison students (M = 46.3, SD = 12.5).	Yes

Source	Hypothesis	Statistical Measurement	Result	Hypothesis Proved Correct?
(Krivoruchko et al., 2015)	Can the use of multimedia sources as a tool within mobile learning be more effective than compared with traditional methods?	Descriptive statistics	Test results indicated an average improvement of language ability, pre-and post-test, of 17.25% for the experimental group and 7.06% for the control group.	Yes
(Zhang et al., 2011)	Can vocabulary teaching on mobile technology be more effective than compared with traditional methods?	T-test	A significant difference existed between the post test results of the experimental group and that of the control group ($t=2.45$, $p<.05$). The significance of this result increased following a delayed test to assess longer-term learning i.e ($t=.47$, $p>.05$).	Yes
(Yin et al., 2013)	Can the use of mobile designed learning systems be more effective as a teaching tool than when compared with face-to-face teaching methods?	T-test	The results indicate that when assessing improvements in conceptual understanding of computer algorithms the experimental groups results were statistically significant ($t = 9.73$, $p < 0.01$).	Yes

Source	Hypothesis	Statistical Measurement	Result	Hypothesis Proved Correct?
(Hung et al., 2012)	Will the learning achievement of students who use PDAs differ from those who use traditional methods?	ANCOVA	Post-test score of the science inquiry ability assessment was greater than the control group ($F(24, 25)=4.72$, $P<0.05$).	Yes
(Wu et al., 2012)	Can the use of mobile learning lead to greater improvements in learning outcomes than compared with traditional methods?	ANCOVA	A significant difference existed between the results of the assessment process for both groups in favour of those participating in M learning ($F=45.26$, $p=0.00<.05$).	Yes
(Chen et al., 2005)	Will independent mobile learning, that is scaffolding at in a six stage process, result in greater improvements in learning achievement than compared with traditional methods?	ANOVA and ANCOVA	Latter stages of the scaffolding process i.e. stages 3 to 6, indicated significant differences between those using M learning and those using traditional methods i.e. stage 3 ($F = 5.343$, $p < 0.05$), stage 4 ($F = 8.515$, $p < 0.01$), stage 5 ($F = 7.250$, $p < 0.01$), and stage 6 ($F = 17.950$, $p < 0.01$).	Yes

Appendix C

The Locations of the BOOLEAN searches conducted in this systematic review are identified below.

The search Strategy used in the ERIC database

http://web.a.ebscohost.com.libezproxy.open.ac.uk/ehost/results?sid=11bc904d-a7c7-4931-89a0-1da61f91aa77%40sessionmgr4010&vid=0&hid=4112&bquery=((TI+mobile+learning)+OR+(KW+mobile+learning)+AND+(KW+learning+style)+OR+(KW+multiple+intelligence)+OR+(KW+differentiation)+OR+(KW+inclusive+learning))+OR+(KW+whole+brain)&bdata=JmRiPWVyaWMmY2xpMD1GVCZjbHYwPVkmY2xpMT1EVDEmY2x2MT0yMDA1MDEtMjAxNjAxJnR5cGU9MSZzaXRlPWVob3N0LWxpdmUmc2NvcGU9c2l0ZQ%3d%3d

The search Strategy used in the British education Index

http://libezproxy.open.ac.uk/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=bri&bquery=((TI+mobile+learning)+OR+(KW+mobile+learning)+AND+(KW+learning+style)+OR+(KW+multiple+intelligence)+OR+(KW+differentiation)+OR+(KW+inclusive+learning))+OR+(KW+whole+brain)&cli0=FT&clv0=Y&cli1=DT1&clv1=200501-201612&type=1&site=ehost-live&scope=site

The search Strategy used in the Science Direct database

http://www.sciencedirect.com.libezproxy.open.ac.uk/science?_ob=ArticleListURL&_method=list&_ArticleListID=-1035530511&_st=17&filterType=&searchtype=a&REC_ARTLIST_ID=-1035528337&originPage=rslt_list&_origin=related_art&_mlktType=Journal&md5=6ae95db4e8b72e47b7a6210c66c05be3

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Appendices

Appendix A: characteristics of studied included within the review

Source	n	Age	Location of Study	Device Used	Subject Area	Type of Study
(Garcia-Cabot et al., 2015)	**30**	Graduate students	Spain	Mobile Device	Web Engineering	Experimental
(Melero et al., 2015)	**76**	Between 14 and 16 years old	Spain	Smart Phone	Art	Experimental
(Rashid & Asghar, 2016)	**761**	20.79 yrs (Mean)	Saudi Arabia	Smart Phone	Unclear	Experimental
(Yang et al., 2015)	**258**	18.96 years (Mean)	China	Smart Phone	Geography, Biology, and Chemistry.	Experimental
(Hwang et al., 2013)	**56**	Aged Between 11 to 12	Taiwan	PDA	Local Culture	Experimental
(Su & Cheng, 2015)	**102**	Aged Between 10–11 years old	Taiwan	Smartphone	Natural Science and Life Technology	Experimental
(Wennersten et al., 2015)	**3,327**	Unclear	India	Mobile Phones	English and Science	Quasi-Experimental
(Yen Lee, C, Chen, I, & Jung-Chuan Yen, C, 2012)	**86**	Unclear	Taiwan	PDA	Local Area Network Planning and Implementation	Experimental
(Alemi et al., 2012)	**45**	Aged between 18- 21.	Iran	Mobile Phones	General English course	Experimental

Source	n	Age	Location of Study	Device Used	Subject Area	Type of Study
(Azabdaftari & Mozaheb, 2012)	**80**	20.5 (Mean)	Iran	Mobile Phones	English literature and Translation at BA level	Experimental
(Basoglu & Akdemir, 2010)	**60**	Unclear	Turkey	Mobile Phones	Undergraduate Compulsory English Preparatory Program	Experimental
(Fattah, 2015)	**30**	20 to 35 years old	Saudi Arabia	Smart Phone	Essay writing	Experimental
(Khazaie & Ketabi, 2011)	**158**	Aged Between 19-23	Iran	Mini-laptop	English recognition and recall	Quasi-Experimental
(Kiger et al., 2012)	**87**	Unclear	USA	iPod touch devices	Mathematics	Experimental
(Krivoruchko et al., 2015)	**82**	Unclear	Kazakhstan	Mobile phones and laptops, net-books. Tablets.	English	Non-Experimental
(Zhang et al., 2011)	**62**	Aged Between 18-22	China	Mobile phones	English	Experimental
(Yin et al., 2013)	**41**	Mean age of 22	Taiwan	PDA's	Computer algorithms	Experimental
(Hung et al., 2012)	**49**	11-12 Years Old	Taiwan	PDA's	Ecology	Experimental
(Wu et al., 2012)	46	Unclear	Taiwan	Mobile device (Specific to Medicine)	Knowledge of the respiratory system	Experimental
(Chen et al., 2005)	**24**	Unclear	Taiwan	PDA	Ecology	Experimental

Appendix B: findings of studies included within the review

Source	Hypothesis	Statistical Measurement	Result	Hypothesis Proved Correct?
(Garcia-Cabot et al., 2015)	"Does mobile learning adaptation impact on learning performance?"	Mann Whitney	The experimental group obtained statistically significantly results i.e. (Mdn = 8.24), U=162.0, p =0.40 compared with the control group i.e. (Mdn = 7.71), U=162.0, p =0.40) indicating the experimental group outperformed the control group.	Yes
(Melero et al., 2015)	Will group work as part of mobile learning lead to improvements in achievement than when compared with non-mobile learning techniques?	T-test	Post test results for those who were part of the experimental group i.e. M learning, indicated statistically significant results than compared with those in the control group (t=2.253, p=<0.05).	Yes
(Rashid & Asghar, 2016)	Does the use of mobile learning, when compared with other techniques, result in greater learning achievement?	Three separate multiple regression	The use of social media, that is incorporated into the learning process as part of mobile learning, had a positive impact upon academic performance (b ¼ 0.14, p < 0.01).	Yes

Source	Hypothesis	Statistical Measurement	Result	Hypothesis Proved Correct?
(Yang et al., 2015)	*Is there* a relationship between mode of learning, interest levels and level of achievement when comparing the use of text, graphical and video content within mobile learning?	Pearson's r	The use of text format in learning is unsuitable for students with high concentration levels similarly video format are unsuitable for those with medium to low concentration levels. Significant yet weak correlations were established between level of interest and concentration (Pearson's r ¼ 0.280, p < 0.01) as well as between concentration and post-test (Pearson's r ¼ 0.206, p < 0.01).	No
(Hwang et al., 2013)	Enquiry-based mobile learning have an effect upon learning achievement and learning attitude?	T-test and ANCOVA	Learning achievement of the experimental group (M learning) was considerably better than that of the control group i.e. F ¼ 4.36 and p 5 0.05.	Yes
(Su & Cheng, 2015)	Will different learning strategies i.e. the use of mobile learning, result in different learning achievements?	T-test and ANCOVA	A large difference was evident in post-examination achievement (p = 0.000) favouring M learning as a more effective teaching strategy.	Yes
(Wennersten et al., 2015)	Will the use of a mixture of subtitled stories, songs, live-action videos, animations and diagrams as a teaching tool in mobile learning result in different learning achievement among learners?	Descriptive statistics	Students who formed part of the experimental group outperformed their counterparts in control schools by an average of 7.92 percentage points.	Yes

Source	Hypothesis	Statistical Measurement	Result	Hypothesis Proved Correct?
(Yen Lee, C, Chen, I, & Jung-Chuan Yen, C, 2012)	Will a difference be evident in the learning achievement of students who use image-based concept mapping compared with text based concept mapping as part of mobile learning?	T-test	No significant differences were found between the teaching methodologies applied and the assessment outcomes ($t = 0.155$, $p = 0.877$). However, there were significant differences between the two groups in relation to the level of understanding ($t = -2.303$, $p = 0.024$) and creating ($t = -2.145$, $p = 0.035$).	No
(Alemi et al., 2012)	"Is there any difference between university students' learning of academic vocabulary items provided via SMS and those learnt by using a dictionary?"	T-test	There was no significant difference between the experimental group and the control group ($t=1.48$, $p= .42$).	No
(Azabdaftari & Mozaheb, 2012)	"Which strategy of vocabulary learning (e.g. flashcards vs. m-learning) is more effective in terms of learning the newly-introduced vocabularies for Iranian EFL learners?"	T-test	The mean calculated for the experimental group was statistically higher than the mean of the control group ($t = 6.99$, $p<0.05$).	Yes
(Basoglu & Akdemir, 2010)	"Is there a difference between the vocabulary learning level of the students using vocabulary learning program in mobile phones before and after the study?"	T-test	The results indicated that there was a statistically significant difference between use of M learning and traditional methods ($t= -7.6$, $p<0.05$).	Yes

Source	Hypothesis	Statistical Measurement	Result	Hypothesis Proved Correct?
(Fattah, 2015)	What is the effectiveness of using 'WhatsApp' i.e. in mobile learning, as a technique to developing students' writing skills?	T-test	The experimental group indicated significant differences in achievement during the assessment process (t= 7.36, P=0.01).	Yes
(Khazaie & Ketabi, 2011)	With the delivery of learning materials via mobile learning that incorporates verbal and visual learning result in differences between participants of learning achievement?	T-test	The use of mobile technology as a learning platform improved learning outcomes for those learning English when audio and visual methods were used together. More importantly, the study revealed that learners with low visual and verbal abilities who were not given text annotation as part of the learning process scored lower than those who received both visual, verbal and textual learning cues during assessment (p=0.000).	Yes
(Kiger et al., 2012)	Does the use of mobile learning result in greater learning achievement than compared with traditional methods?	Descriptive statistics	The mean results for M learning students indicated that more items were answered correctly on the post intervention multiplication test (M = 54.5, SD = 14.8) than the Comparison students (M = 46.3, SD = 12.5).	Yes

Source	Hypothesis	Statistical Measurement	Result	Hypothesis Proved Correct?
(Krivoruchko et al., 2015)	Can the use of multimedia sources as a tool within mobile learning be more effective than compared with traditional methods?	Descriptive statistics	Test results indicated an average improvement of language ability, pre-and post test, of 17.25% for the experimental group and 7.06% for the control group.	Yes
(Zhang et al., 2011)	Can vocabulary teaching on mobile technology be more effective than compared with traditional methods?	T-test	A significant difference existed between the post test results of the experimental group and that of the control group ($t=2.45$, $p<.05$). The significance of this result increased following a delayed test to assess longer-term learning i.e ($t=.47$, $p>.05$).	Yes
(Yin et al., 2013)	Can the use of mobile designed learning systems be more effective as a teaching tool than when compared with face-to-face teaching methods?	T-test	The results indicate that when assessing improvements in conceptual understanding of computer algorithms the experimental groups results were statistically significant ($t = 9.73$, $p < 0.01$).	Yes

Source	Hypothesis	Statistical Measurement	Result	Hypothesis Proved Correct?
(Hung et al., 2012)	Will the learning achievement of students who use PDAs differ from those who use traditional methods?	ANCOVA	Post-test score of the science inquiry ability assessment was greater than the control group ($F(24, 25)=4.72$, $P<0.05$).	Yes
(Wu et al., 2012)	Can the use of mobile learning lead to greater improvements in learning outcomes than compared with traditional methods?	ANCOVA	A significant difference existed between the results of the assessment process for both groups in favour of those participating in M learning ($F=45.26$, $p=0.00<.05$).	Yes
(Chen et al., 2005)	Will independent mobile learning, that is scaffolding at in a six stage process, result in greater improvements in learning achievement than compared with traditional methods?	ANOVA and ANCOVA	Latter stages of the scaffolding process i.e. stages 3 to 6, indicated significant differences between those using M learning and those using traditional methods i.e. stage 3 ($F = 5.343$, $p < 0.05$), stage 4 ($F = 8.515$, $p < 0.01$), stage 5 ($F = 7.250$, $p < 0.01$), and stage 6 ($F = 17.950$, $p < 0.01$).	Yes

Appendix C

The Locations of the BOOLEAN searches conducted in this systematic review are identified below.

The search Strategy used in the ERIC database

http://web.a.ebscohost.com.libezproxy.open.ac.uk/ehost/results?sid=11bc904d-a7c7-4931-89a0-1da61f91aa77%40sessionmgr4010&vid=0&hid=4112&bquery=((TI+mobile+learning)+OR+(KW+mobile+learning)+AND+(KW+learning+style)+OR+(KW+multiple+intelligence)+OR+(KW+differentiation)+OR+(KW+inclusive+learning))+OR+(KW+whole+brain)&bdata=JmRiPWVyaWMmY2xpMD1GVCZjbHYwPVkmY2xpMT1EVDEmY2x2MT0yMDA1MDEtMjAxNjAxJnR5cGU9MSZzaXRlPWVob3N0LWxpdmUmc2NvcGU9c2l0ZQ%3d%3d

The search Strategy used in the British education Index

http://libezproxy.open.ac.uk/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=bri&bquery=((TI+mobile+learning)+OR+(KW+mobile+learning)+AND+(KW+learning+style)+OR+(KW+multiple+intelligence)+OR+(KW+differentiation)+OR+(KW+inclusive+learning))+OR+(KW+whole+brain)&cli0=FT&clv0=Y&cli1=DT1&clv1=200501-201612&type=1&site=ehost-live&scope=site

The search Strategy used in the Science Direct database

http://www.sciencedirect.com.libezproxy.open.ac.uk/science?_ob=ArticleListURL&_method=list&_ArticleListID=-1035530511&_st=17&filterType=&searchtype=a&REC_ARTLIST_ID=-1035528337&originPage=rslt_list&_origin=related_art&_mlktType=Journal&md5=6ae95db4e8b72e47b7a6210c66c05be3