Mobile Learning Content Authoring Tools (MLCATs): A Systematic Review

Raymond Mugwanya[1] and Gary Marsden[2]

ICT4D Lab, Department of Computer Science, University of Cape Town, South Africa
ray.mugwanya@gmail.com, gaz@cs.uct.ac.za

Abstract. Mobile learning is currently receiving a lot of attention in the education arena, particularly within electronic learning. This is attributed to the increasing mobile penetration rates and the subsequent increases in university student enrolments. Mobile Learning environments are supported by a number of crucial services such as content creation which require an authoring tool. The last decade or so has witnessed increased attention on tools for authoring mobile learning content for education. This can be seen from the vast number of conference and journal publications devoted to the topic. Therefore, the goal of this paper is to review works that were published, suggest a new classification framework and explore each of the classification features. This paper is based on a systematic review of mobile learning content authoring tools (MLCATs) from 2000 to 2009. The framework is developed based on three broad dimensions i.e. Technology, Pedagogy and Usability and a number of features such as system type, development context, Tools and Technologies used, tool availability, ICTD relation, Multimedia support, tool purpose, support for standards, learning style support, intuitive Graphical User Interface and accessibility. This paper provides a means for researchers to extract assertions and several important lessons for the choice and implementation of MLCATs.

Keywords: Mobile Education, Content Authoring Tools, Systematic Review.

1 Introduction

Mobile and ubiquitous learning is emerging as the next generation of education environments. This is partly due to the high mobile penetration rates and subsequent increases in university student enrolments [11][44][55]. Therefore, learning demands from mobile devices are increasing thus presenting challenges for content creation [17][29]. In order to deal with these demands, quality content creation is of paramount importance. Authoring tools are the programs used by academics to create and distribute content in various domains [61]. A tool is considered to be a MLCAT if the resulting content can be consumed on mobile devices. The use of authoring tools is not a simple task for academics who wish to author electronic content [20][54]. This may be due to steep learning curve(s),

A. Villafiorita, R. Saint-Paul, and A. Zorer (Eds.): AFRICOMM 2009, LNICST 38, pp. 20–31, 2010.

some academics being technology shy and resistant to change or possibly inadequate institutional support. The goal of MLCATs is to empower academics (even the recalcitrant ones) to easily author content that is consumable on mobiles so as to provide anywhere, anytime learning. Over time, many researchers have made efforts to design and implement MLCATs thus there is great diversity in both commercial and non commercial tools [36]. These tools are developed with various goals and purposes in mind resulting in a variety of architectures. Some tools, for example, are used to author tests [61][44][3][40]), support content re-use [29] and support content authoring for integration with Learning Management Systems (LMS)[37][44][55] and present video lectures [25][47][48][64]among others. Numerous articles have been published in journals and conferences relating to MLCATs, suggesting a lot of interest in the design and implementation of innovative MLCATs. Therefore, we feel that this is a good time to review MLCATs. The aim of this paper is to classify and summarize research relevant to M-Learning content authoring tools, provide a framework for the integration and classification of articles and to derive suggestions for M-Learning researchers based on the review. The rest of this paper is organized as follows; section 2 details the procedure we followed to conduct the systematic review and outlines the characteristics of our primary studies, section 3 explores our classification framework while sections 4 and 5 detail the classification framework results, summary and conclusions respectively.

2 Procedure

Our primary studies were selected based on the keyword search *'mobile learning and content authoring tool*'* for the period 2000 to 2009, using eight online databases. A total of 142 articles were generated from our initial search. The number of articles by online database are as follows: ACM Digital Library (96), EBSCOHOST (Electronic Journal Service) (02), Emerald (03), GALE (04),

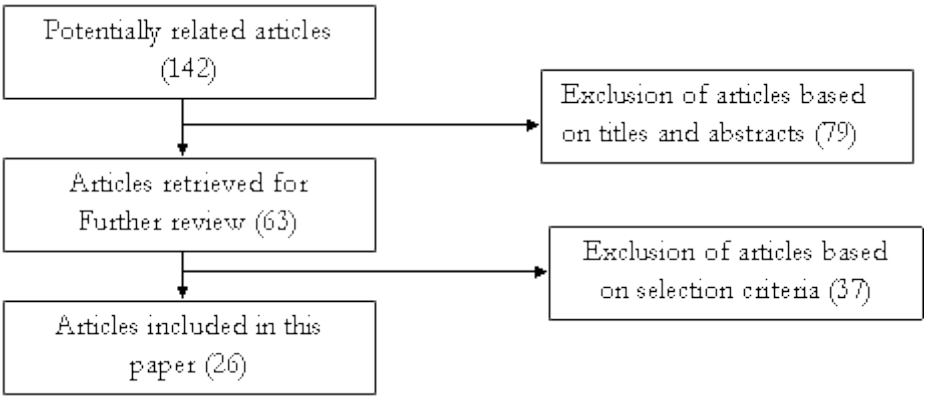

Fig. 1. Procedure for selection of articles

IEEE Xplore (08), Science Direct (05), Springer (02) and Google Scholar (21). A total of 79 articles were excluded based on their titles and abstracts. This was followed by a further inclusion/exclusion of articles based on whether they contained MLCAT literature as their core. 63 articles met the selection criteria and were presented for further review. 37 articles were then excluded because despite having relevant titles, abstracts and full text, they did not present relevant tools for this study.

2.1 Classification of MLCAT Articles by Publication Year

Figure 2 shows the number of MLCAT articles by publication year. It can be noted that from 2002 to 2005, there was an increase in articles published, with 2005 registering the highest number of articles. From then on, MLCAT publications declined by half in the 2006, 2007 period with a further slight decline in 2008 and 2009. This may be attributed to the fact that many published systems rarely move past the experimental stage and the need for universities to justify the case for investment in learning technologies. However, many published tools have been successfully used in the various contexts for which they have been developed.Therefore, we believe that the next decade will be characterized by increased interest and development of mobile learning content authoring tools.

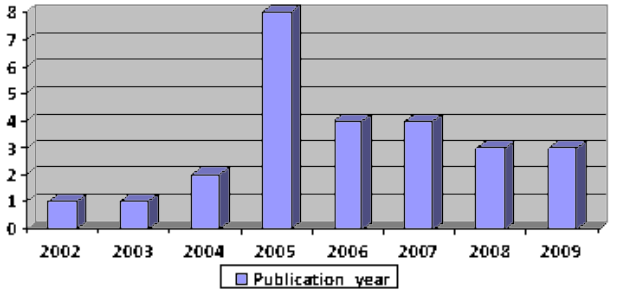

Fig. 2. Number of articles by publication year

3 Classification Framework

In this section, we present our classification framework which offers an analysis of MLCATs. According to [37][70] and a report by Taylor et al.on best practices for instructional design and content development for mobile learning, we identify three broad dimensions to classify MLCATs namely; technology, pedagogy and Usability. We feel that they constitute the necessary and sufficient attributes for the development or choice of adoption of MLCATs. Similarly, [9][70] suggest that technology is a critical enabler for mobile learning but the major challenges lie with content authoring, delivery strategy (Pedagogy), the need for a

GUI and accessibility support (Usability). We further sub-divide technological features (while providing their corresponding acronyms) as follows: system type (Sys Typ.), authoring techniques and technologies used (Techno.), tool Availability (Av.), ICTD relation (ICTD), tool purpose and Multimedia support (MM). Pedagogical requirements comprise of standards (Stds.) and learning style (LS) support whereas usability requirements include existence of an intuitive graphical user interface (GUI) and accessibility (Acc.).

We distinguish several system types i.e. artificial intelligence tools (A), traditional authoring tools that use hypertext and multimedia features for content creation (T), video capture systems (V) and natural language speaking and handwriting tools (N). Artificial intelligence tools enable academics to create intelligent tutoring systems in their domain of expertise through a graphical user interface. The tool then models student usage characteristics so as to provide them with individualized guidance during learning [61]. Video capture tools involve recording, encoding and streaming of the instructors presentations for consumption on various end devices [62] whereas natural language speaking and handwriting tools use recognition software to convert speech and hand written material into editable objects (i.e. text, video, audio or graphics) which are authored for presentation on end devices[35]. We also give an indication of whether a tool offers desktop authoring (DA), mobile authoring (MA), content distribution to mobile (DM), desktops (DD)or both (DMD) and use ?? for a lack of feature support.

The second dimension explores the authoring techniques and development environments used; for example, some tools use single authoring (S) a technique used to create a single version of content for adaptation to any given end device, Multiple authoring (M) which involves creation of several content versions for the different consumer devices and Flexible authoring (F) which involves the creation of both single and multiple authored content versions [37]. The development environments include, among others, J2ME, eXtensible Markup Language (XML), .NET framework and Synchronized Multimedia Integration Language (SMIL) among others. In the next dimension, we classify tools against their availability. This implies that a tool is either Web based (w), Client based (c), has a downloadable version available (d) or can be purchased (p). The fourth dimension classifies tools based on whether they are developed with a developing world (ICTD) context in mind. The developing world is faced with various challenges such as those of infrastructure, poverty, literacy and sparsity.

The last two dimensions classify tools based on their purpose and the multimedia supported. The tools explored are used to create learning content, multiple choice quizzes, tests and video lectures among others. In addition, the tools support various media elements such as video (v), text (t), audio (a) and images (i). Within the pedagogical arena, we explore two features i.e. standards and learning styles. There are various standards available for mobile learning content authoring such as the Sharable Content Object Reference Model (SCORM) [1] and the IMS Global Learning Consortium Question and Test Interoperability [21]. Moreover, support for learning style and activity of learners such visual,

tactile and other learning theories should be taken into account during content authoring for m-learning. Therefore, we classify tools based on their support for standards and learning styles. Within the usability arena, we classify tools based on whether they have an intuitive graphical user interface and/or support accessibility(support for people with disabilities).

4 Results of Classification

A total of 26 tools have been classified as illustrated in Table 1 below revealing some interesting observations. From a technology perspective, the biggest number of MLCATs are traditional tools those that use hypertext and multimedia features for content creation [3][7][9][15][17][20] [29][36][42][44][50][51][55], followed by video recording tools [24][47][48][64], artificial intelligence tools [37][42] [61] and natural language processing tools [3]. The LMS concept has been successful in many universities. Therefore, as a result majority of the tools are developed with the goal of being integrated into Learning Management Systems. For example, [44] is designed for integration into the AHA! System, [55] into Moodle and [37] into the Context-based adaptive Mobile Learning Environment (CoMoLE). In addition, many of the tools have been developed for desktop authoring, with some also providing for mobile authoring [36][61] and the greatest number supporting distribution of content for access on both mobile devices (smart phones, iPods, cell phones, etc.) and computers.

Herzog et al. argue that video content is not mandatory in most learning environments due limitations such as the need for constant internet bandwidth availability. Therefore, it is still a challenge to implement video recording within LMS architectures. A number of video recording tools have emerged based on the initial innovations by Apple i.e. [64] which allows video lectures to be recorded and content delivered to mobile devices such as iPods. The resulting content cannot be later changed, implying single authoring. The majority of tools in our review use this authoring approach with [29][36] offering flexible authoring. We note that a vast number of tool articles do not give an indication of the authoring techniques used hence the use of ?? in our matrix. The natural language processing tools use hand-writing software, screen capture software and video streaming for content delivery and the matrix also reveals that majority of the tools are either web-based or client tools with only [55] having a demo version available whereas [64] can be purchased.

In much of the developing world, infrastructure is characterized by little or no internet bandwidth, unreliable and intermittent mains electricity and limited user expertise among others. This implies that the developing world context requires ICTD relevant tools. Majority of the tools explored are developed for user contexts in the developed world and thus do not represent the needs of academics and learners in the developing world. For instance in much of sub-Saharan Africa, despite the huge investments by universities on LMSs such as Blackboard and WebCT, the impact of their use has not been significant. Several programmes have been offered through distance education but still heavily rely on first generation print and second generation face-to-face lectures [11].

Table 1. Tool Classification Matrix showing MLCATs Vs Dimensions

Dim.	Technology						Pedagogy		Usability	
Tool	**Sys Typ.**	**Auth.Tech and Techno.**	**Av.**	**ICTD**	**Tool purpose**	**MM.**	**Stds.**	**LS**	**GUI**	**Acc.**
[**29**]	T,DA, DMD	F, XML, XSLT	w	No	learning content and tests	t, i, a, v	Yes	No	Yes	No
[**46**]	T,DA, DMD	S, Java and XML	w	No	adaptive tests	t, i	No	No	No	No
[**61**]	A, MA, DA, DMD	S, ASP.NET, VB.NET, Windows Server 2000+, IIS, RDBMS	w	No	adaptive content and tests	t, i	No	Yes(Intelligence)	No	No
[**37**]	A,DA, DMD	?, Java, XML	w	No	Learning content	t, i	No	Yes	Yes	No
[**52**]	T, DA, DMD	S, XML, XHTML, CSS	c	No	Learning content	t, i, a	No	No	Yes	No
[**35**]	N,DA, DMD	??, hand writing, screen capture.,video streaming software	??	Yes	Learning content	t, i, v	No	No	No	No
[**25**]	??, DA,DMD	??, XML	??	No	Learning content	t, i, v	No	Yes(Learning Activity)	??	No
[**36**]	T,MA, DM	F, Visual C++, Pocket PC2003 OS	??	No	Learning content	t, i, v	No	No	??	No
[**57**]	T, D,DA, DMD	??, XHTML, XML	d	No	Learning content	t,i, v	Yes	Yes	??	No
[**3**]	T, DA, DM	??, SMS	c	No	quizzes answered through SMS	t, i	No	No	No	No
[**3**]	T, DA, DM	??, Palmtop, e-mail, MMS	w	No	interactive learning tasks for learner groups	t, i, a	No	Yes	??	No
[**3**]	T, DA, DM	??, PocketPC	c	No	Multiple choice quizzes	t, i	No	No	??	No
[**51**]	T, D, DA, DMD	??, Java, XML, XHTML	w	No	Learning content	t, i, v	No	No	Yes	No
[**7**]	T, DA, DMD	??, XML, RFID, GPS	w	No	Learning content	t, i, a	No	No	Yes	No
[**44**]	T, D,DA, DMD	??, XML	w	No	exercises of different types	t, i	No	Yes	No	No
[**17**]	T, D, DA, DMD	??, C sharp, XML	??	No	Learning content	t, i	No	Yes	??	No
[**42**]	A, DA, D	??,XML, HTML, CSS	c	No	Learning content and Tests	t, i , a, v, hyperlinks	Yes	No	Yes	No
[**64**]	V, DMD	??, Streaming Server, SMIL, MPEG-4	p	No	Learning content	Video podcasts, t,i,a	Yes	No	No	No
[**9**]	T, DA, DMD	??, SMIL	w	No	multimedia content	t, i, a, v	??	No	Yes	No
[**48**]	V, DA, DMD	??, ??	??	No	Instant multimedia content	t, i, a	??	No	Yes	No
[**62**]	??, DA, DD	??, XML, XSLT Style Sheets, XHTML	w	No	multimedia content	t, i, a	??	No	??	No
[**20**]	??, DA, MA, DMD	??, Java	w	No	examples	t, i,v	No	No	Yes	No
[**50**]	??, DA, MA, DMD,	??, Java	w	No	Tests, assess-ment, collabora-tive activities	t, i,a	??	No	Yes	No
[**24**]	V, DMD	??, Java 2D, Java Media Frameworks	c	No	Creating video centered educational spaces	t, i,v	No	No	??	??
[**15**]	??, HTTP, WAP, Web Services	??	w	No	multimedia content	t, i, a, v	No	No	??	No
[**47**]	??, H.264, MPEG-4	??	??	No	multimedia content	t, i, a, v	No	No	No	No

In addition, many of the tools in our matrix are developed with the sole purpose of creating learning content [25][29][37][52] whereas others are for authoring adaptive tests [44][61], quizzes [3][42] and for authoring instant multimedia (i.e. podcasts, vodcasts) [47][48][64]. Therefore, the majority of tools generate various combinations of multimedia elements i.e. text and images [37][44][61], text, images and video [24][34][35] whereas others support most media types [9][29][42][47]. Within the pedagogical arena we explored support for standards and learning style. This is because these aspects greatly impact on content creation. Our review revealed that some tools offer support for standards such as the sharable content reference model (SCORM) or the Question and Test Interoperability (QTI) [29][42][55][64] whereas [3][17][25][44][55][61] offer support for learning styles. Finally, the usability dimension explores the availability of an intuitive graphical user interface (GUI) and support for accessibility which deals with the provision for people with learning disabilities to utilize the tools. [7][9][17][20][29][37][48][50][52] have GUIs built into the MLCATs whereas none of the tools offer support for accessibility.

5 Summary and Conclusions

Our review was organized with the purpose of providing a comprehensive overview of research on MLCATs. Therefore, we reviewed MLCATs and examined them using the technology, pedagogy and usability dimensions as presented in our cross-tabulation matrix. The paper was based on a literature review of MLCATs from 2000 to 2009 using a keyword index and article title search. Overall, we found that the research activity related to MLCATs increased dramatically up to 2005 and then decreased slightly from then on to 2009.

Our review provides literature on the use of MLCATs and avails some insights to researchers and practitioners for the design and choice of tool adoption. The framework offers some general development considerations for MLCATs and offers a classification of the various tools. We also realize the need for tools to be developed within the contexts of the users in order for successful adoption of these technologies. Many of the MLCATs explored do not use design approaches that involve real system users in context. Therefore, we need to develop MLCATs that represent the needs of users and empower them to author content for use in mobile environments. Moreover, the varieties of tool implementations explored are mainly technology driven. We feel that in order for them to satisfy their intended needs which is facilitate the learning process, tool implementations should follow an integrated approach that takes into account usability and pedagogical aspects. We believe that this will lead to better design, increased use and adoption of MLCATs.

Although considerable attention was given to the classification framework design, some limitations still exist. Firstly, some relevant articles might have been overlooked as much of the literature was selected based on a review of the title, keyword or abstract only. In addition, despite the fact that titles and abstracts in most cases describe the content quite well, we excluded many articles that did

not explore MLCATs as their core. White papers, dissertations, magazines and many articles related to MLCATs were not reviewed as our focus was journal and conference articles which presumably represent the highest level of peer reviewed research. As a result seven online databases were searched for our review. We also used university subscribed online databases which were restricted in some cases. Future work requires the need to adapt learning activities to personalization of course content based on students model and learning styles, ability to track students progress in mobile environments, provide feedback mechanisms and improve interactivity. There is also need to study and align the relationship between authoring technology, pedagogy concerns, usability, the ability to create content using mobile devices without the need for additional processing and the need to empower academics who are the domain experts to easily create content without the need for intervention by tool experts.

Acknowledgements

Our thanks to the Hasso Plattner Institute Research School, University of Cape Town and the Faculty of Computing and IT, Makerere University for their support without which this work would not have been possible.

References

1. Advanced Distributed Learning Website, `http://www.adlnet.org/Pages/Default.aspx`
2. Anacleto, J.C., Carlos, A.J., de Carvalho, A.F., Dias, A.L.: Bridging the gap among cultures: the challenge faced by teachers on producing content for computer-aided education. In: Proceedings of the 26th Annual ACM international Conference on Design of Communication, SIGDOC 2008, ACM, New York (2008)
3. Attewell, J.: From Research and Development to Mobile Learning: Tools for Education and Training Providers and their Learners. In: Proceedings of mLearn (2005), `http://www.mlearn.org.za/CD/papers/Attewell.pdf`
4. Brown, E., Cristea, A., Stewart, C., Brailsford, T.: Patterns in Authoring of Adaptive Educational Hypermedia: A Taxonomy of Learning Styles. Educational Technology and Society 8(3), 77–90 (2005)
5. Berlanga, A.J., García, F.J.: Authoring tools for adaptive learning designs in computer-based education. In: Proceedings of the 2005 Latin American Conference on Human-Computer interaction, vol. 24, pp. 190–201. ACM, New York (2005)
6. Bhaskar, N.U., Govindarajulu, P.: Essential Aspects of Learning content Development in Context Aware and Adaptive Mobile Learning Applications. International Journal of Computer Science and Network Security 9(1), 339–346 (2009)
7. Broll, G., Rukzio, R., Björn, W.: Authoring Support for Mobile Interaction with the Real World. In: Pervasive Late Breaking Results, Toronto, Ontario, Canada (2007); Bianchi, M.: Automatic video production of lectures using an intelligent and aware environment. In: Proceedings of the 3rd international Conference on Mobile and Ubiquitous Multimedia, vol. 83. ACM, New York (2004)
8. Bianchi, M.: Automatic video production of lectures using an intelligent and aware environment. In: Proceedings of the 3rd international Conference on Mobile and Ubiquitous Multimedia, vol. 83. ACM, New York (2004)

9. Bulterman, D.C., Hardman, L.: Structured multimedia authoring. ACM Trans. Multimedia Comput. Commun. Appl. 1, 89–109 (2005)
10. Collins, T.G.: English Class on the Air: Mobile Language Learning with Cell Phones. In: Proceedings of the Fifth IEEE International Conference on Advanced Learning Technologies, p. 1 (2005)
11. Ngugi, C., Irungu, N., Muwonge, B., Langa, P.V., Pederson, J., Butcher, N., Hoosen, S., Moll, I., Adam, F., Backhouse, J., Mhlanga, E., Kouame, G., Tolba, A., Mutti, B., Eden, C.: Status Report on ICTs and Higher Education in Africa. Published by the Centre of Educational Technology, University of Cape Town, SA (2007)
12. Chandra, S.: Lecture video capture for the masses. SIGCSE Bull. 39, 3 (2007)
13. Cebeci: Using podcasts as audio learning objects. Interdisciplinary Journal of Knowledge and Learning Objects 1552-2210, 2, 47 (2006)
14. Chu, W. C., Lin, H., Chen, J., Lin, X., Lau, R.W.H.: Context-sensitive content representation for mobile learning. In: Lau, R., Li, Q., Cheung, R., Liu, W. (eds.) ICWL 2005. LNCS, vol. 3583, pp. 349–354. Springer, Heidelberg (2005)
15. de, F., Santos, H., Santana, L.H., Martins, D.S., De Souza, W.L., do Prado, A.F., Biajiz, M.: A ubiquitous computing environment for medical education. In: Proceedings of the 2008 ACM Symposium on Applied Computing, pp. 1395–1399. ACM, New York (2008)
16. Friedland, G., Hürst, W., Knipping, L.: Educational multimedia systems: the past, the present, and a glimpse into the future. In: Proceedings of the international Workshop on Educational Multimedia and Multimedia Education, pp. 1–4. ACM, New York (2007)
17. Gugerbauer, E.: Analysis of the Profit of M-Learning and A Framework for Authoring Mobile Learning Content, http://www.tk.uni-linz.ac.at/download/gugerbauer.pdf
18. Hürst, W., Welte, M., Jung, S.: An evaluation of the mobile usage of e-lecture podcasts. In: Proceedings of the 4th international Conference on Mobile Technology, Applications, and Systems and the 1st international Symposium on Computer Human interaction in Mobile Technology, pp. 16–23. ACM, New York (2007)
19. Herzog, M. A., Trier, M., Sieck, J.: Production engineering for video based e- and m-learning content. In: 10th Baltic Region Seminar on Engineering Education? 2006 UICEE Szczecin, Poland, pp. 1–4 (2006)
20. Hsiao, I., Li, Q., Lin, Y.: Educational social linking in example authoring. In: Proceedings of the Nineteenth ACM Conference on Hypertext and Hypermedia, pp. 229–230. ACM, New York (2008)
21. IMS Content Packaging Specification v1.1.3, http://www.imsglobal.org/content/packaging/
22. IMS Global Learning Consortium – Question and Test Interoperability, http://www.imsglobal.org/question/version2.0
23. IEEE Standard for Learning Object Metadata, http://ltsc.ieee.org/wg12
24. Jiang, H., Viel, A., Bajaj, M., Lue, R.A., Shen, C.: CThru: exploration in a video-centered information space for educational purposes. In: Proceedings of the 27th international Conference on Human Factors in Computing Systems, pp. 1247–1250. ACM, New York (2009)
25. Juang, Y., Chen, Y., Chen, Y., Chan, T.: Design of Learning Content Development Framework and System for Mobile Technology Enhanced Environment. In: Proceedings of the IEEE International Conference on Advanced Learning Technologies, pp. 1–3 (2004)

26. Jokela, T.: Authoring Toos for Mobile Multimedia Content. In: ICME, pp. 637–640 (2003)
27. Karampiperis, P., Sampson, D.: Designing learning systems to provide accessible services. In: Proceedings of the international Cross-Disciplinary Workshop on Web Accessibility (W4a), vol. 88, pp. 72–80. ACM, New York (2005)
28. Karampiperis, P., Sampson, D.: Designing learning services: from content-based to activity-based learning systems. In: Special interest Tracks and Posters of the 14th international Conference on World Wide Web, pp. 1110–1111. ACM, New York (2005)
29. Kuo, Y., Huang, Y.: MEAT: An authoring tool for generating adaptable learning resources (Mobile E-Learning Authoring Tool) (Report). Journal of Educational Technology and Society 51(18) (2009); Academic One File
30. Lichtschlag, L., Karrer, T., Borchers, J.: Fly: a tool to author planar presentations. In: Proceedings of the 27th international Conference on Human Factors in Computing Systems. ACM, New York (2009)
31. Leitner, M., Wolkerstorfer, P., Sefelin, R., Tscheligi, M.: Mobile multimedia: identifying user values using the means-end theory. In: Proceedings of the 10th international Conference on Human Computer interaction with Mobile Devices and Services, pp. 167–175. ACM, New York (2008)
32. Lara, E.d., Kumar, R., Wallach, D.S., Zwaenepoel, W.: Collaboration and multimedia authoring on mobile devices. In: Proceedings of the 1st international Conference on Mobile Systems, Applications and Services, pp. 287–301. ACM, New York (2003)
33. Lanir, J., Booth, K.S., Tang, A.: MultiPresenter: a presentation system for (very) large display surfaces. In: Proceeding of the 16th ACM international Conference on Multimedia, pp. 519–528. ACM, New York (2008)
34. Low, B.: Packaging educational content using IMS specifications. VINE 32(2) (2002)
35. Luciano, C., Guisseppe, S.: Pen-based tools for the creation of handwritten learning content. In: IEEE First International Workshop on Pen-Based Learning Technologies - Enabling Advanced Graphical, Multimodal and Mobile Learning Interactions, pp. 133–136 (2007)
36. Li, S., Kim, S., Kim, S.: Collaborative MPEG-4 Contents Authoring, Presentation and Interaction in a Mobile Environment. In: Proceedings of the Sixth International Conference on Parallel and Distributed Computing, Applications and Technologies, pp. 1–5 (2005)
37. Martín, E., Carro, R.M.: Supporting the Development of Mobile Adaptive Learning Environments: A Case Study. IEEE Transactions on Learning Technologies 2(1), 23–36 (2009)
38. MobiLearn IST-2001-37187, `http://www.mobilearn.org/standards/standards.htm`
39. MOT, `http://wwwis.win.tue.nl/~acristea/mot.html`
40. Metso, M., Koivisto, A., Sauvola, J.: A Content Model for the Mobile Adaptation of Multimedia Information. The Journal of VLSI Signal Processing 29 (2001)
41. McFarlane, A., Williams, J.M., Bonnett, M.: Assessment and multimedia authoring a tool for externalising understanding. Journal of Computer Assisted Learning 16(3), 201–212 (2000)
42. Kravcik, M., Specht, M.: Authoring Adaptive Courses: ALE APPROACH. Advanced Technology for Learning 1(4) (2004), `actapress.com`

43. Näsänen, J., Oulasvirta, A., Lehmuskallio, A.: Mobile media in the social fabric of a kindergarten. In: Proceedings of the 27th international Conference on Human Factors in Computing Systems, pp. 2167–2176. ACM, New York (2009)
44. Proske, A., Narciss, S., Korndle, H.: The Exercise Format Editor. A Multimedia Tool for the Design of Multiple Learning Tasks (2002), http://studierplatz2000.tu-dresden.de/lehrlern/pdf/artikel/ef_editor02.pdf
45. Röüling, G., Trompler, C., Mühlhäuser, M., Köbler, S., Wolf, S.: Enhancing classroom lectures with digital sliding blackboards. In: Proceedings of the 9th Annual SIGCSE Conference on innovation and Technology in Computer Science Education, pp. 218–222. ACM, New York (2004)
46. Romero, C., Ventura, S., Hervas, C., De Bra, P.: An Authoring Tool for Building Both Mobile Adaptable Tests and Web Based Adaptive or Classic Tests. In: Wade, V.P., Ashman, H., Smyth, B. (eds.) AH 2006. LNCS, vol. 4018, pp. 203–212. Springer, Heidelberg (2006)
47. Roesler, V., Husemann, R., Costa, C.H.: A new multimedia synchronous distance learning system: the IVA study case. In: Proceedings of the 2009 ACM Symposium on Applied Computing, pp. 1765–1770. ACM, New York (2009)
48. Rubegni, E., Sabiescu, A., Paolini, P.: OneThousandAndOneStories: a format for multichannel multimedia narratives. In: Abascal, J., Fajardo, I., Oakley, I. (eds.) Proceedings of the 15th European Conference on Cognitive Ergonomics: the Ergonomics of Cool interaction, vol. 369, pp. 1–2. ACM, New York (2008)
49. Rößling, G., Joy, M., Moreno, A., Radenski, A., Malmi, L., Kerren, A., Naps, T., Ross, R.J., Clancy, M., Korhonen, A., Oechsle, R., Iturbide, J.Á.: Enhancing learning management systems to better support computer science education. SIGCSE Bull. 40(4), 142–166 (2008)
50. Sá, M., Carriço, L.: Handheld devices for cooperative educational activities. In: Proceedings of the 2006 ACM Symposium on Applied Computing, pp. 1145–1149. ACM, New York (2006)
51. Smith, S.: Creating Mobile Learning? (2006), http://www.handheldlearning.co.uk/hl2006/present/stuartsmith.pdf
52. Simon, R., Wegscheider, F., Tolar, K.: Tool-supported single authoring for device independence and multimodality. In: Proceedings of the 7th international Conference on Human Computer interaction with Mobile Devices and Amp; Services, vol. 111, pp. 91–98. ACM, New York (2005)
53. Sharda, N.K.: Authoring educational multimedia content using learning styles and story telling principles. In: Proceedings of the international Workshop on Educational Multimedia and Multimedia Education, pp. 93–102. ACM, New York (2007)
54. Tortora, G., Sebillo, M., Vitiello, G., D'Ambrosio, P.: A multilevel learning management system. In: Proceedings of the 14th international Conference on Software Engineering and Knowledge Engineering, vol. 27, pp. 541–547. ACM, New York (2002)
55. Tai, Y., Ting, R. Y.: Authoring Tools in e-Learning: A Case Study. In: Seventh IEEE International Conference on Advanced Learning Technologies, pp. 1–3 (2007)
56. The International Telecommunications Union Website (Market Information and Statistics), http://www.itu.int/ITU-D/ict/statistics/ict/index.html
57. The SourceForge.Net Website: eXeLearning Tool, http://apps.sourceforge.net/trac/exe/wiki
58. Teng, C., Chu, H., Wu, C.: mProducer: Authoring Multimedia Personal Experiences on Mobile Phones. In: IEEE International Conference on Multimedia and Expo., pp. 1251–1254 (2004)

59. Turban, G., Mühlhäuser, M.: A framework for the development of educational presentation systems and its application. In: Proceedings of the international Workshop on Educational Multimedia and Multimedia Education, pp. 115–118. ACM, New York (2007)
60. Van Dam, A., Becker, S., Simpson, R.M.: Next-generation educational software: why we need it and a research agenda for getting it. In: ACM SIGGRAPH 2007 Courses, p. 32. ACM, New York (2007)
61. Virvou, M., Alepis, E.: Mobile Educational Features in Authoring Tools for Personalised Tutoring. Computers and Education 44(1), 53–68 (2005)
62. Valverde-Albacete, F.J., Pedraza-Jiménez, R., Cid-Sueiro, J., Molina-Bulla, H., Díaz-Pérez, P., Navia-Vázquez, A.: InterMediActor: an environment for instructional content design based on competences. In: Proceedings of the 2003 ACM Symposium on Applied Computing, pp. 575–579. ACM, New York (2003)
63. Weal, M.J., Hornecker, E., Cruickshank, D.G., Michaelides, D.T., Millard, D.E., Halloran, J., De Roure, D.C., Fitzpatrick, G.: Requirements for in-situ authoring of location based experiences. In: Proceedings of the 8th Conference on Human-Computer interaction with Mobile Devices and Services, vol. 159, pp. 121–128. ACM, New York (2006)
64. Wolf, K., Linckels, S., Meinel, C.: Teleteaching anywhere solution kit (Tele-TASK) goes mobile. In: Proceedings of the 35th Annual ACM SIGUCCS Conference on User Services, pp. 366–371. ACM, New York (2007)
65. Zhang, C., Rui, Y., Crawford, J., He, L.: An automated end-to-end lecture capture and broadcasting system. ACM Trans. Multimedia Comput. Commun., 1–23 (2008)
66. Ihamäki, H., Vilpola, I.: Electronic Journal on e-Learning 2(1) (2004), http://www.ejel.org/volume-2/vol2-issue1/issue1-art18-ihamaki-vilpoloa.pdf
67. Adell, J., Castellet, J.M., Gumbau, J.P.: Selection of an open source virtual learning environment for Universitat JaumeI (2004), http://cent.uji.es/doc/eveauji_en.pdf
68. Nielsen, J.: Finding usability problems through heuristic evaluation, pp. 373–380. ACM Press, New York (1992)
69. Leung, C., Chan, Y.: Mobile Learning: A New Paradigm. In: Electronic Learning Proceedings of the 3rd IEEE International Conference on Advanced Learning Technologies, pp. 1–5 (2003), http://www.te.ugm.ac.id/~widyawan/mobilearn/MobilearnParadigm.pdf
70. Taylor, J., Bo, G., Bernazzani, R., Sharples, M.: WP4 - Pedagogical Methodologies and Paradigms (2005), http://www.mobilearn.org/download/results/public_deliverables/MOBIlearn_D4.2_Final.pdf