ΠΑΝΕΠΙΣΤΗΜΙΟ ΠΕΙΡΑΙΩΣ

Τμήμα Ψηφιακών Συστημάτων

ΜΕΘΟΔΟΙ ΚΑΙ ΣΥΣΤΗΜΑΤΑ ΓΙΑ ΤΗΝ ΑΝΟΙΚΤΗ ΠΡΟΣΒΑΣΗ, ΤΟ ΔΙΑΜΟΙΡΑΣΜΟ ΚΑΙ ΤΗΝ ΕΠΑΝΑΧΡΗΣΙΜΟΠΟΙΗΣΗ ΨΗΦΙΑΚΟΥ ΕΚΠΑΙΔΕΥΤΙΚΟΥ ΠΕΡΙΕΧΟΜΕΝΟΥ ΚΑΙ ΕΚΠΑΙΔΕΥΤΙΚΩΝ ΔΡΑΣΤΗΡΙΟΤΗΤΩΝ

ΔΙΔΑΚΤΟΡΙΚΗ ΔΙΑΤΡΙΒΗ

του

ΠΑΝΑΓΙΩΤΗ Δ. ΖΕΡΒΑ

Πειραιάς, 2014

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ΠΑΝΑΓΙΩΤΗ Δ. ΖΕΡΒΑ

Η διατριβή υποβάλλεται για την κάλυψη των απαιτήσεων

απόκτησης Διδακτορικού Διπλώματος

Πειραιάς, 2014

Παναγιώτης Δ. Ζέρβας

Υποψήφιος Διδάκτορας Πανεπιστημίου Πειραιώς

UNIVERSITY OF PIRAEUS

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METHODS AND SYSTEMS FOR SUPPORTING OPEN ACCESS AND REUSE TO EDUCATIONAL RESOURCES AND PRACTICES

A Thesis

Presented to

The Academic Faculty

by

PANAGIOTIS D. ZERVAS

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Keywords:

Learning Objects, Learning Activities, Learning Designs, Educational Metadata, Educational Courses, Open Access, Reuse, Hierarchical Model, Reuse Model, Learning Object Repositories, Learning Technologies Standards, e-Learning Systems

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Extended Summary (in Greek)

Α. Ορισμός Προβλήματος

Τα τελευταία χρόνια υπάρχει μια αυξανόμενη τάση για την ανοιχτή πρόσβαση σε ψηφιακό εκπαιδευτικό περιεχόμενο, η οποία εκφράζεται από το συνεχές ενδιαφέρον της ερευνητικής αλλά και εκπαιδευτικής κοινότητας για τον όρο **Open Educational Resources** (OER) (Caswel et al., 2008). Ο όρος OER υιοθετήθηκε για πρώτη φορά στο διεθνές συνέδριο της UNESCO με τίτλο "Forum on the Impact of Open Courseware for Higher Education in Developing Countries" και αναφέρεται στην «*ανοιχτή πρόσβαση και παροχή ψηφιακού εκπαιδευτικού περιεχομένου στην εκπαιδευτική κοινότητα για μη-εμπορικούς σκοπούς που μπορεί να εμπλουτισθεί, βελτιωθεί και αναδιανεμηθεί, για χρήση στη διδασκαλία και την μάθηση*» (UNESCO, 2002).

Σε ανταπόκριση του αυξανόμενου ενδιαφέροντος για τον όρο OER μια σειρά από διεθνείς πρωτοβουλίες έχουν αναπτυχθεί από μεγάλους εκπαιδευτικούς οργανισμούς όπως η πρωτοβουλία OpenCourseWare (OCW) του Massachusetts Institute of Technology, η πρωτοβουλία iTunes του Πανεπιστημίου του Stanford και η πρωτοβουλία Connexions του Πανεπιστημίου του Rice, ενώ αντίστοιχες πρωτοβουλίες πραγματοποιούνται από κοινότητες χρηστών ή κοινοπραξίες όπως η πρωτοβουλία του MERLOT και του OER Commons (Ehlers, 2011; Walsh, 2010). Τα αναμενόμενα οφέλη των OERs για τους εκπαιδευτικούς και τους εκπαιδευόμενους μπορούν να συνοψιστούν ως εξής (Geser, 2007): (α) είναι ελεύθερα για χρήση, (β) μπορούν να χρησιμοποιηθούν ή/και να επαναχρησιμοποιηθούν στην διδασκαλία και την μάθηση (συνήθως με προσδιορισμό του δημιουργού τους), (γ) μπορούν να τροποποιηθούν για διαφορετικά εκπαιδευτικά πλαίσια χρήσης (context of use) και (δ) η ανάπτυξη τους αποτελεί μια παγκόσμια τάση και συνεπώς εκπαιδευτικές κοινότητες μπορούν να δημιουργηθούν γύρω από αυτά.

Όπως συνήθως συμβαίνει με την εμφάνιση νέων όρων δεν υπάρχει ένας κοινά αποδεκτός ορισμός σχετικά με τον όρο OER. Σύμφωνα με τους διάφορους ορισμούς που είναι διαθέσιμοι στην διεθνή βιβλιογραφία, ο όρος OER μπορεί να ερμηνευτεί σαν (α) ανοικτή πρόσβαση σε ψηφιακό εκπαιδευτικό περιεχόμενο, (β) ανοικτή

πρόσβαση σε ακαδημαϊκά μαθήματα και (γ) λογισμικό ανοικτού κώδικα (Friesen, 2009). Αυτό πρακτικά σημαίνει ότι ο όρος OER δεν αφορά μόνο την ανοικτή πρόσβαση σε ψηφιακό εκπαιδευτικό περιεχόμενο αλλά μπορεί να αναφέρεται σε διαφορετικά επίπεδα συσσώρευσης ή σε διαφορετικούς τύπους ψηφιακού εκπαιδευτικού περιεχομένου (Wilson & McAndrew, 2011; Lane & McAndrew, 2010).

Παρόλα αυτά υπάρχουσες διεθνείς πρωτοβουλίες που προωθούν την χρήση OERs δεν χειρίζονται με διαφορετικό τρόπο τα OERs σύμφωνα με τα διαφορετικά επίπεδα συσσώρευσης τους. Το βασικό μειονέκτημα αυτών των προσεγγίσεων είναι ότι συνήθως υιοθετούν ένα ενιαίο (μη-αρθρωτό) μοντέλο χρήσης για την υποστήριξη των βασικών φάσεων μια τυπικής αλυσίδας Ηλεκτρονικής Μάθησης (δηλαδή, δημιουργία, δημοσίευση, αναζήτηση, ανάκτηση, πρόσβαση, χρήση, επαναχρησιμοποίηση και διάθεση των OERs) που δεν λαμβάνει υπόψη τις ιδιαιτερότητες των διαφορετικών επιπέδων συσσώρευσης τους (δηλαδή, ψηφιακό εκπαιδευτικό περιεχόμενο, εκπαιδευτικές δραστηριότητες[1], ηλεκτρονικά μαθήματα[2] και προγράμματα ηλεκτρονικής εκπαίδευσης και/ή κατάρτισης[3]) αλλά και τα διαφορετικά τεχνολογικά εργαλεία που απαιτούνται για τον χειρισμό των ιδιαιτεροτήτων αυτών. Συνεπώς, αποτελεί μια σημαντική πρόκληση στο πεδίο της Τεχνολογικά-Υποστηριζόμενης Μάθησης ο ορισμός και η συστηματική περιγραφή (ενέργειες, ρόλοι, τεχνολογικά εργαλεία) κατάλληλων αρθρωτών (modular) και ιεραρχικών μοντέλων που υποστηρίζουν τις βασικές φάσεις μιας τυπικής αλυσίδας Ηλεκτρονικής Μάθησης και μπορούν εν τέλει να υποστηρίξουν την ανοικτή πρόσβαση στην εκπαίδευση και την μάθηση.

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[1] Ως **εκπαιδευτική δραστηριότητα** (Learning Activity) ορίζεται: *"η ενέργεια που έχει σχεδιαστεί να υλοποιηθεί από έναν ή πολλούς εκπαιδευόμενους εντός ενός κατάλληλα σχεδιασμένου εκπαιδευτικού περιβάλλοντος (το οποίο περιλαμβάνει: εργαλεία, εκπαιδευτικό περιεχόμενο, υπηρεσίες) με ή χωρίς την υποστήριξη εκπαιδευτών, προκειμένου να επιτευχθούν συγκεκριμένοι μαθησιακοί στόχοι και αποτελέσματα"* (Beetham, 2007).

[2] Ως **ηλεκτρονικό μάθημα** ορίζεται: "*η σύνθεση εκπαιδευτικών δραστηριοτήτων που ακολουθούν μια συγκεκριμένη παιδαγωγική στρατηγική*" (Alonso, 2005).

[3] Ως **Πρόγραμμα Ηλεκτρονικής Εκπαίδευσης και/ή Κατάρτισης** ορίζεται: "*η σύνθεση ηλεκτρονικών μαθημάτων που ακολουθούν μια συγκεκριμένη παιδαγωγική στρατηγική και πραγματοποιούνται με την υποστήριξη ηλεκτρονικών τάξεων*" (Daniels, 2009).

Από την άλλη πλευρά, τα **Μαθησιακά Αντικείμενα** (Learning Objects)[4] αποτελούν έναν κοινό τρόπο ανάπτυξης και διαμοιρασμού ψηφιακού εκπαιδευτικού περιεχομένου που βασίζεται στον αρθρωτό σχεδιασμό αλλά δεν περιλαμβάνουν κατ' ανάγκη την ανοιχτή πρόσβαση. Συνεπώς κάποιος θα μπορούσε να ισχυριστεί ότι τα OERs συνδέονται άμεσα με τα μαθησιακά αντικείμενα αν θεωρήσουμε ότι υιοθετούν άδειες ανοικτής πρόσβασης (Friesen, 2009; Lane & McAndrew, 2010). Τα μαθησιακά αντικείμενα μαζί με τα μεταδεδομένα τους οργανώνονται κατηγοριοποιούνται, αποθηκεύονται και διατίθενται μέσω ψηφιακών βιβλιοθηκών που αναφέρονται ως Βιβλιοθήκες Μαθησιακών Αντικειμένων (Learning Object Repositories - LORs) (McGreal, 2004)**.** Η ανάπτυξη Βιβλιοθηκών Μαθησιακών Αντικειμένων στοχεύει κυρίως στην ενίσχυση της επαναχρησιμοποίησης των Μαθησιακών Αντικειμένων (Ochoa & Duval, 2008; McGreal, 2008) . Αυτό είναι επίσης μια σημαντική πρόκληση στο πεδίο της Τεχνολογικά-Υποστηριζόμενης Μάθησης (Vuorikari & Koper, 2009; McGreal, 2008; Van Assche & Vuorikari, 2006) λόγω του υψηλού κόστους ανάπτυξης ποιοτικού ψηφιακού εκπαιδευτικού περιεχομένου (Zimmermann et al., 2006).

Με βάση τα παραπάνω, η **διδακτορική διατριβή** συνεισφέρει στα εξής θέματα:

- τον ορισμό και την συστηματική περιγραφή (ενέργειες, ρόλοι, τεχνολογικά εργαλεία) ενός αρθρωτού (modular) ιεραρχικού μοντέλου που υποστηρίζει τις βασικές φάσεις μιας τυπικής αλυσίδας Ηλεκτρονικής Μάθησης και εν τέλει την ανοικτή πρόσβαση στην εκπαίδευση και την μάθηση
- τον ορισμό και την συστηματική περιγραφή ενός μοντέλου ροής εργασίας (workflow) για τον κύκλο ζωής και την επαναχρησιμοποίηση των μαθησιακών αντικειμένων προκειμένου να εξεταστούν προϋποθέσεις οικονομικά συμφέρουσας επαναχρησιμοποίησης των μαθησιακών αντικειμένων

[4] Ως **Μαθησιακό Αντικείμενο (Learning Object)** ορίζεται: *"κάθε ψηφιακή πηγή περιεχομένου η οποία μπορεί να επαναχρησιμοποιηθεί για να υποστηρίξει τη μάθηση"* (Wiley, 2002)

- την εφαρμογή και αξιολόγηση του εν λόγω αρθρωτού ιεραρχικού μοντέλου για την υποστήριξη της ηλεκτρονικής κατάρτισης Ατόμων με Αναπηρία (ΑμεΑ) και την εκμάθηση ξένων γλωσσών μέσω κινητών συσκευών

Β. Περιγραφή Αποτελεσμάτων Έρευνας

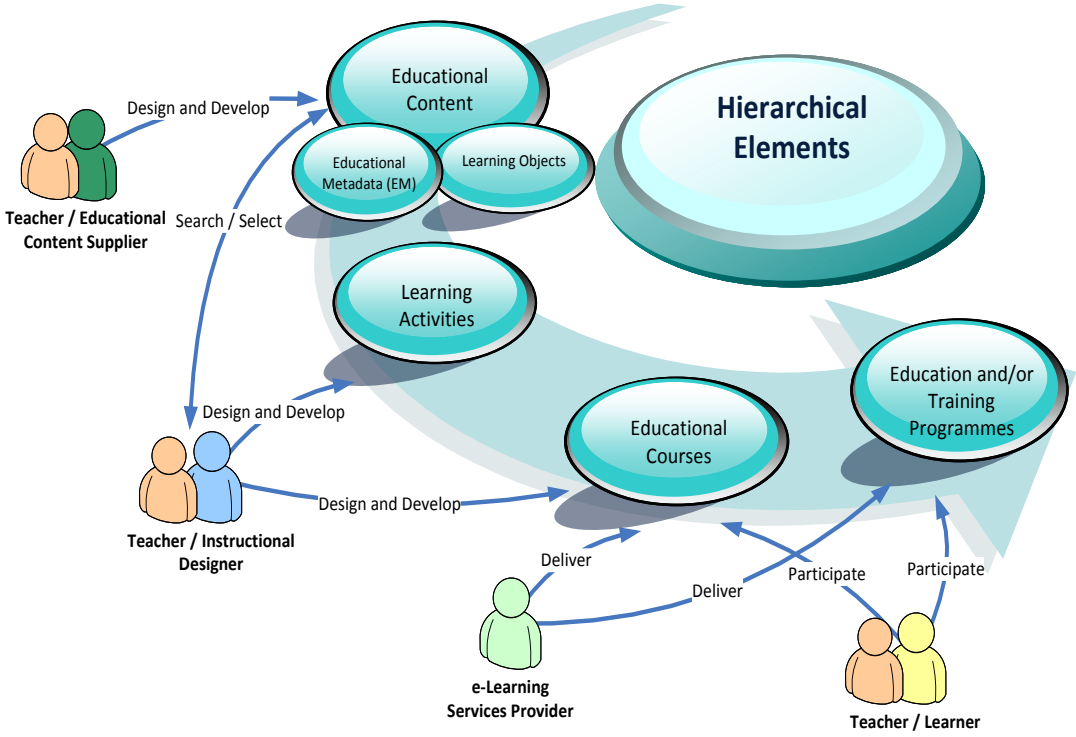
Η διδακτορική αυτή διατριβή ασχολείται με θέματα που αφορούν *τον ορισμό ιεραρχικού μοντέλου που υποστηρίζει ανοικτή πρόσβαση στην εκπαίδευση και την μάθηση*, *τον ορισμό και την συστηματική περιγραφή μοντέλου ροής εργασίας (workflow) για τον κύκλο ζωής και την επαναχρησιμοποίηση των μαθησιακών αντικειμένων* καθώς και την *αξιολόγηση του εν λόγω αρθρωτού ιεραρχικού μοντέλου για την υποστήριξη της ηλεκτρονικής κατάρτισης Ατόμων με Αναπηρία (ΑμεΑ) και την εκμάθηση ξένων γλωσσών μέσω κινητών συσκευών*. Πιο συγκεκριμένα:

Αρθρωτό Ιεραρχικό Μοντέλο για τη Ανοικτή Πρόσβαση στην Εκπαίδευση και την Μάθηση

Βασικός στόχος αυτής της ερευνητικής προσπάθειας ήταν να περιγραφεί ένα ιεραρχικό μοντέλο (περιλαμβάνοντας ρόλους, ενέργειες και τεχνολογικά εργαλεία) για την υποστήριξη των βασικών φάσεων μια τυπικής αλυσίδας Ηλεκτρονικής Μάθησης δηλαδή, την δημιουργία, την δημοσίευση, την αναζήτηση, την ανάκτηση, την πρόσβαση, την χρήση, την επαναχρησιμοποίηση και την διάθεση των OERs. Το ιεραρχικό μοντέλο ορίστηκε με σκοπό να υποστηρίξει την διαδικασία της αρθρωτής (modular) σχεδίασης, επαναχρησιμοποιώντας ιεραρχικά στοιχεία (elements) του μοντέλου σε διαφορετικά επίπεδα. Ειδικότερα το προτεινόμενο ιεραρχικό μοντέλο παρουσιάζεται στην Εικόνα 1 και αναγνωρίζει 4 βασικά ιεραρχικά στοιχεία τα οποία είναι: (α) εκπαιδευτικό περιεχόμενο, το οποίο περιλαμβάνει OERs σε μορφή μαθησιακών αντικειμένων και τα μεταδεδομένα τους που χρησιμοποιούνται για να περιγράψουν τα εκπαιδευτικά χαρακτηριστικά των μαθησιακών αντικειμένων, (β) εκπαιδευτικές δραστηριότερες, (γ) ηλεκτρονικά μαθήματα και (δ) προγράμματα ηλεκτρονικής εκπαίδευσης και/ή κατάρτισης. Επιπλέον, οι βασικοί ρόλοι που αναγνωρίζονται στο προτεινόμενο ιεραρχικό μοντέλο όπως παρουσιάζονται και στην Εικόνα 1 είναι οι ακόλουθοι: (α) Δημιουργοί Εκπαιδευτικού Περιεχομένου, (β) Ειδικοί Εκπαιδευτικού Σχεδιασμού, (γ) Πάροχοι Υπηρεσιών Ηλεκτρονικής Μάθησης,

(δ) Εκπαιδευτικοί και (ε) Εκπαιδευόμενοι. Τέλος, το προτεινόμενο ιεραρχικό μοντέλο υποστηρίζεται και από οκτώ (8) τεχνολογικά εργαλεία που σκοπό έχουν να καλύψουν τις ανάγκες των βασικών ρόλων του προτεινόμενου ιεραρχικού μοντέλου.

Τα αποτελέσματα αυτής της έρευνας (προτεινόμενο ιεραρχικό μοντέλο και τεχνολογικά εργαλεία που το υποστηρίζουν) έχουν δημοσιευτεί στο διεθνές περιοδικό "International Journal of Web Based Communities" [P2] και έχουν παρουσιαστεί στο διεθνές συνέδριο «3rd International Conference on e-Learning and Distance Learning (ELI 2013)» [P6].

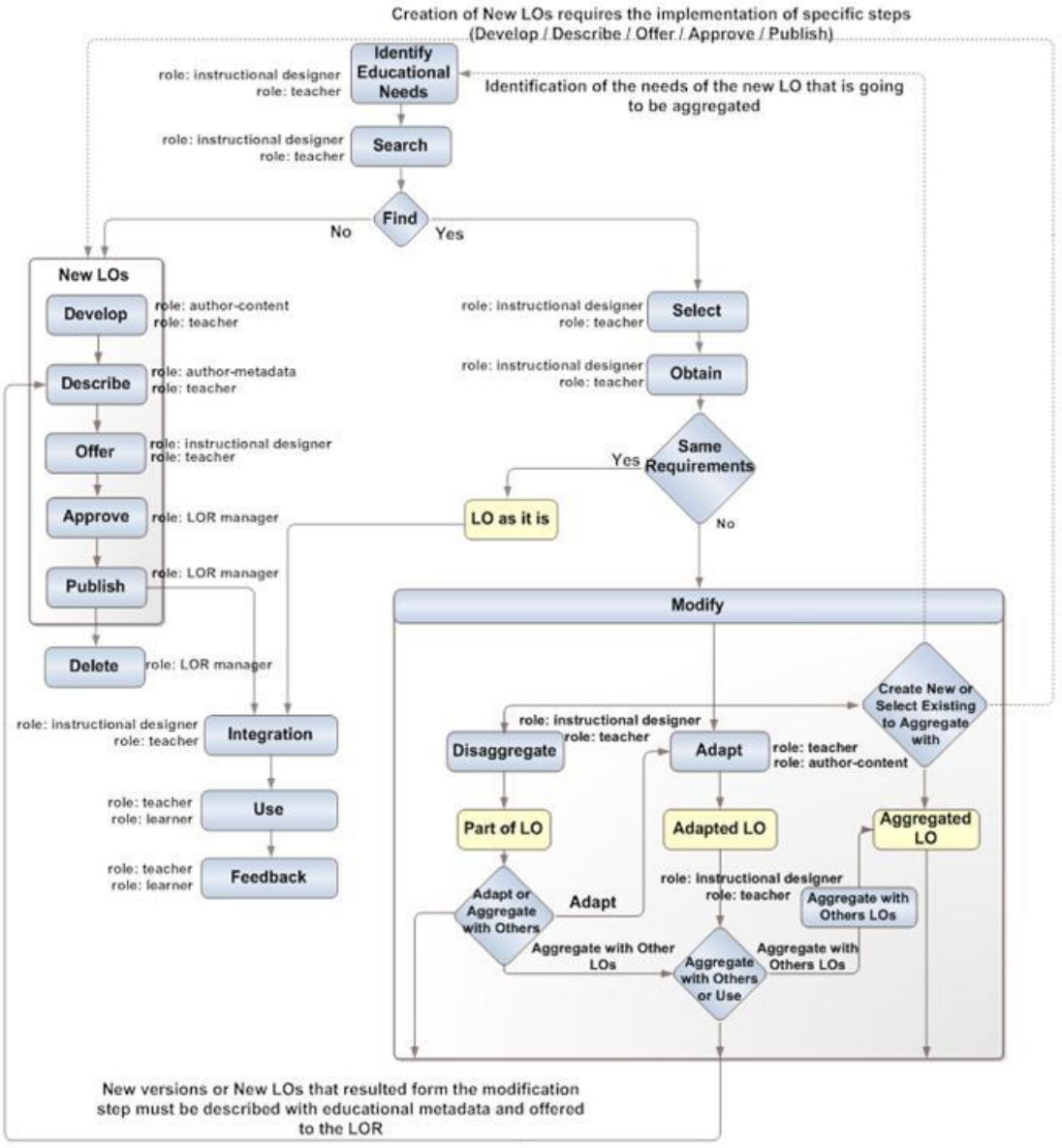


Εικόνα 1: Προτεινόμενο Ιεραρχικό Μοντέλο για την υποστήριξη της Ανοικτής Πρόσβασης στην Εκπαίδευση και την Μάθηση

Μοντέλο Ροής Εργασίας για τον Κύκλο Ζωής και την Επαναχρησιμοποίηση Μαθησιακών Αντικειμένων

Βασικός στόχος αυτής της ερευνητικής προσπάθειας ήταν να επικεντρωθούμε στο χαμηλότερο στοιχείο (element) του προτεινόμενου ιεραρχικού μοντέλου δηλαδή στο εκπαιδευτικό περιεχόμενο και να εξετάσουμε την διαδικασία της επαναχρησιμοποίησης των Μαθησιακών Αντικειμένων. Ειδικότερα μελετήθηκε η

διαδικασία επαναχρησιμοποίησης των μαθησιακών αντικειμένων για τον σχεδιασμό και ανάπτυξη εκπαιδευτικών δραστηριοτήτων και ορίστηκε ένα μοντέλο ροής εργασίας που καταγράφει την εν λόγω διαδικασία όπως παρουσιάζεται στην Εικόνα 2.



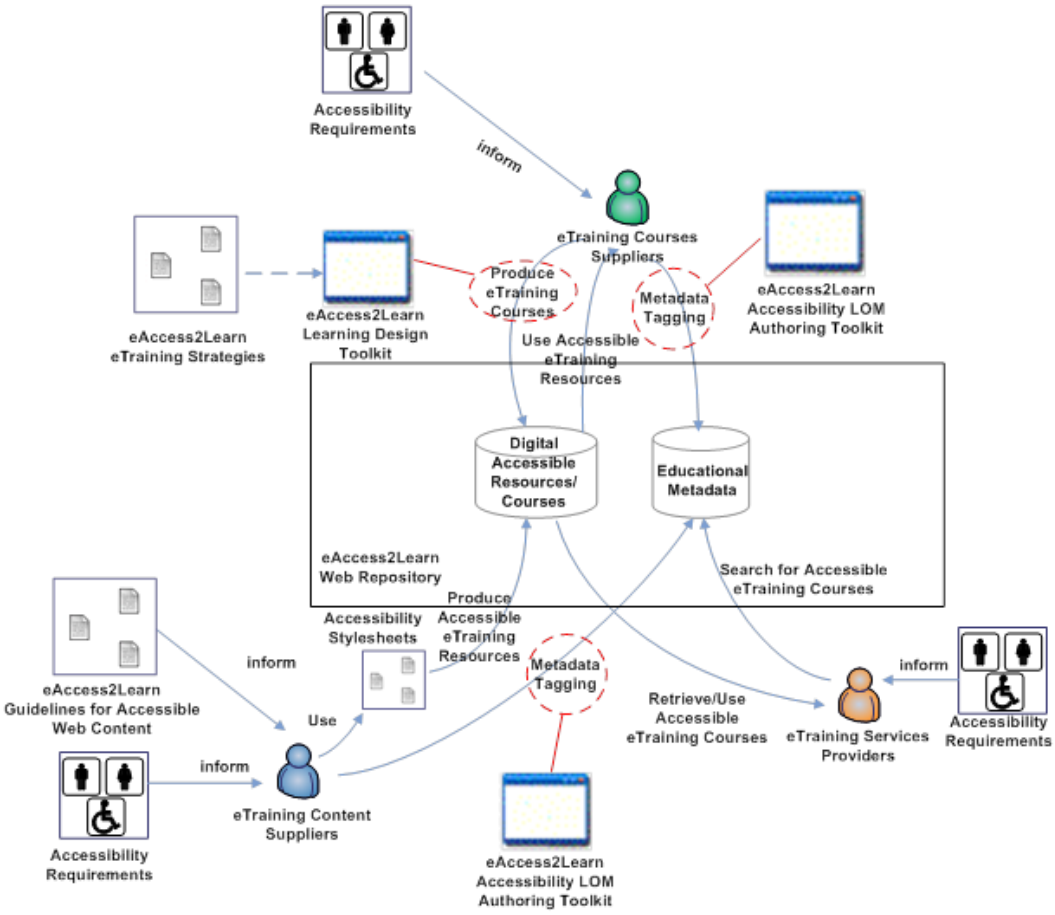
Εικόνα 2: Προτεινόμενο Μοντέλο Ροής Εργασίας για τον Κύκλο Ζωής και την Επαναχρησιμοποίηση Μαθησιακών Αντικειμένων (ΜΑ)

Με βάση το προτεινόμενο μοντέλο ροής εργασίας ορίστηκαν μια σειρά από μετρικές για την μέτρηση του κόστους της επαναχρησιμοποίησης Μαθησιακών Αντικειμένων ενώ εξετάστηκαν και προϋποθέσεις οικονομικά συμφέρουσας επαναχρησιμοποίησης των Μαθησιακών Αντικειμένων.

Τα αποτελέσματα αυτής της έρευνας (προτεινόμενο μοντέλο ροής εργασίας και μετρικές κόστους επαναχρησιμοποίησης μαθησιακών αντικειμένων) έχουν δημοσιευτεί στο διεθνές περιοδικό «Educational Technology & Society Journal» [P4] σε ειδικό τεύχος με θέμα: Advanced Learning Technologies και έχουν παρουσιαστεί στο διεθνές συνέδριο «11th IEEE International Conference on Advanced Learning Technologies (ICALT 2011)» [P8].

Εφαρμογή Προτεινόμενου Ιεραρχικού Μοντέλου για την Υποστήριξη της Ηλεκτρονικής Κατάρτισης Ατόμων με Αναπηρία

Βασικός στόχος αυτής της ερευνητικής προσπάθειας ήταν η εφαρμογή του προτεινόμενου ιεραρχικού μοντέλου που είχαμε ήδη ορίσει με σκοπό την υποστήριξη της ηλεκτρονικής κατάρτισης Ατόμων με Αναπηρία (ΑμεΑ). Η Εικόνα 3 παρουσιάζει την εφαρμογή του προτεινόμενου ιεραρχικού μοντέλου για την υποστήριξη της ηλεκτρονικής κατάρτισης ΑμεΑ.



Εικόνα 3: Εφαρμογή Προτεινόμενου Ιεραρχικού Μοντέλου για την Υποστήριξη της Ηλεκτρονικής Κατάρτισης ΑμεΑ

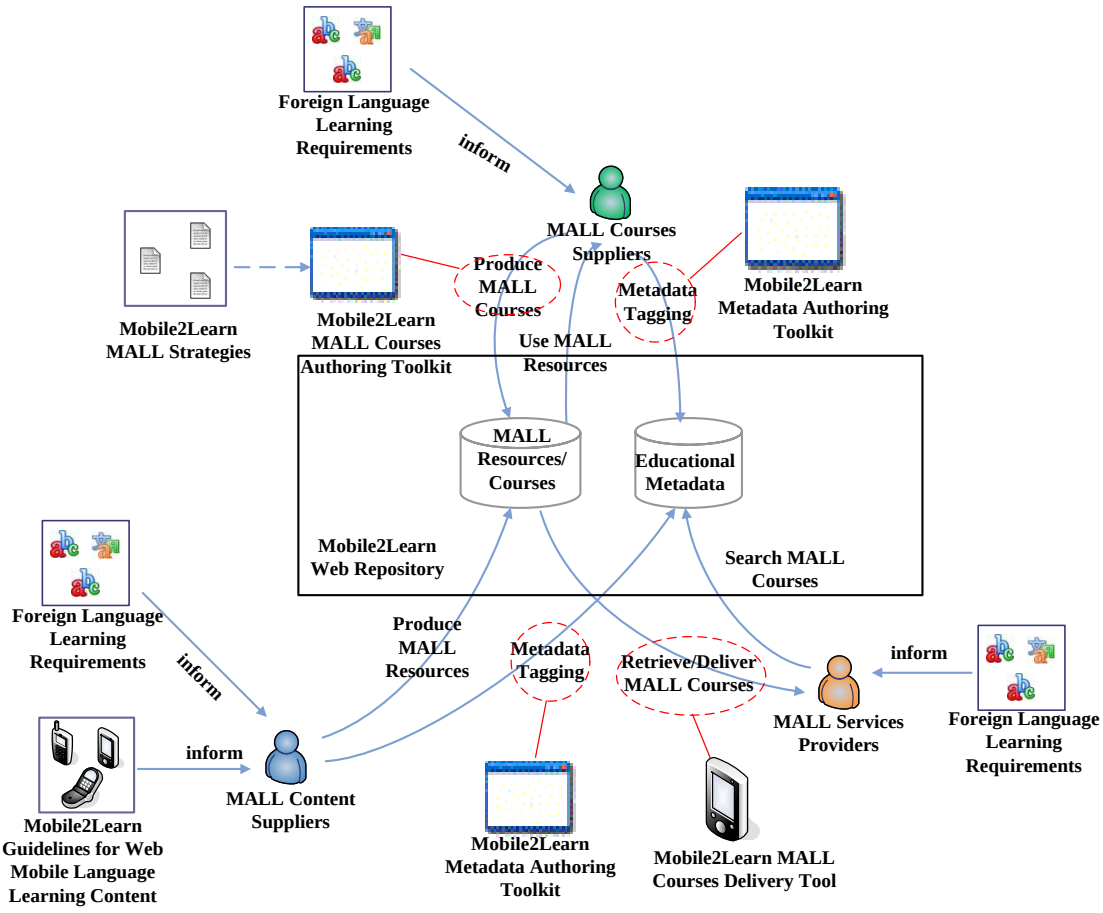
Στο εν λόγω στιγμιότυπο του προτεινόμενου ιεραρχικού μοντέλου αναγνωρίστηκαν τρεις (3) ρόλοι ήτοι (α) Πάροχοι Ηλεκτρονικού Εκπαιδευτικού Περιεχομένου, (β) Πάροχοι Ηλεκτρονικών Εκπαιδευτικών Μαθημάτων και (γ) Πάροχοι Υπηρεσιών Ηλεκτρονικής Κατάρτισης ΑμεΑ. Επιπλέον, αναγνωρίστηκαν τέσσερα (4) τεχνολογικά εργαλεία με σκοπό να καλύψουν τις ανάγκες των ρόλων του αναγνωρίστηκαν.

Τέλος, πραγματοποιήθηκαν μια σειρά από πειράματα με δύο (2) ομάδες ΑμεΑ (άτομα με κινητικά προβλήματα και άτομα με προβλήματα όρασης) με σκοπό να μελετηθεί η επαναχρησιμοποίηση των μαθησιακών αντικειμένων για τον σχεδιασμό και την ανάπτυξη Ηλεκτρονικών Μαθημάτων για τις δύο προαναφερθείσες ομάδες ΑμεΑ με την χρήση του προτεινόμενου ιεραρχικού μοντέλου.

Τα αποτελέσματα αυτής της έρευνας (εφαρμογή προτεινόμενο μοντέλου και πειράματα μέτρησης της επαναχρησιμοποίησης των μαθησιακών αντικειμένων) έχουν δημοσιευτεί στο διεθνές περιοδικό «IEEE Transactions on Learning Technologies» [P3] και έχουν παρουσιαστεί στο διεθνές συνέδριο «2nd International Conference on Intelligent Networking and Collaborative Systems (INCoS 2010)» [P9] όπου έλαβαν και Best Paper Award.

Εφαρμογή Προτεινόμενου Ιεραρχικού Μοντέλου για την Υποστήριξη της Εκμάθησης Ξένων Γλωσσών Μέσω Κινητών Συσκευών

Βασικός στόχος αυτής της ερευνητικής προσπάθειας ήταν η εφαρμογή του προτεινόμενου ιεραρχικού μοντέλου που είχαμε ήδη ορίσει με σκοπό την υποστήριξη της Εκμάθησης Ξένων Γλωσσών μέσω Κινητών Συσκευών. Η Εικόνα 4 παρουσιάζει την εφαρμογή του προτεινόμενου ιεραρχικού μοντέλου για την υποστήριξη της Εκμάθησης Ξένων Γλωσσών μέσω Κινητών Συσκευών.



Εικόνα 4: Εφαρμογή Προτεινόμενου Ιεραρχικού Μοντέλου για την Υποστήριξη της Εκμάθησης Ξένων Γλωσσών μέσω Κινητών Συσκευών

Στο εν λόγω στιγμιότυπο του προτεινόμενου ιεραρχικού μοντέλου αναγνωρίστηκαν τρεις (3) ρόλοι ήτοι (α) Πάροχοι Ηλεκτρονικού Εκπαιδευτικού Περιεχομένου, (β) Πάροχοι Ηλεκτρονικών Εκπαιδευτικών Μαθημάτων και (γ) Πάροχοι Υπηρεσιών Ηλεκτρονικής Κατάρτισης για την εκμάθηση ξένων γλωσσών μέσω κινητών συσκευών. Επιπλέον, αναγνωρίστηκαν πέντε (5) τεχνολογικά εργαλεία με σκοπό να καλύψουν τις ανάγκες των ρόλων του αναγνωρίστηκαν.

Τέλος, πραγματοποιήθηκαν μια σειρά από πειράματα με σκοπό να μελετηθεί η επαναχρησιμοποίηση των μαθησιακών αντικειμένων για τον σχεδιασμό και την ανάπτυξη Ηλεκτρονικών Μαθημάτων για την εκμάθηση ξένων γλωσσών μέσω κινητών συσκευών με την χρήση του προτεινόμενου ιεραρχικού μοντέλου αλλά και να αναγνωριστούν τυχόν παράγοντες που επηρεάζουν την επαναχρησιμοποίηση των μαθησιακών αντικειμένων.

Τα αποτελέσματα αυτής της έρευνας (εφαρμογή προτεινόμενο μοντέλου και πειράματα μέτρησης της επαναχρησιμοποίησης των μαθησιακών αντικειμένων) έχουν δημοσιευτεί στο διεθνές περιοδικό «IEEE Transactions on Learning Technologies» [P1] και έχουν παρουσιαστεί σε 3 διεθνή συνέδρια ήτοι στο «13th IEEE International Conference on Advanced Learning Technologies (ICALT 2013)» [P5], στο «12th IEEE International Conference on Advanced Learning Technologies (ICALT 2012)» [P7] και στο «10th IEEE International Conference on Advanced Learning Technologies (ICALT 2010)» [P10].

Publications based on this Thesis

Four (4) papers published in International Journals and six (6) papers published in proceedings of Scientific Conferences.

International Journal Papers

[P1] D. Sampson and P. Zervas, "A Hierarchical Framework for Open Access to Education and Learning", International Journal of Web Based Communities, vol. 10(1), pp. 25-51, Inderscience Publishers, January 2014

[P2] P. Zervas and D. Sampson, "Facilitating Teachers' Reuse of Mobile Assisted Language Learning Resources using Educational Metadata", IEEE Transactions on Learning Technologies, IEEE Computer Society, (in press), http://dx.doi.org/10.1109/TLT.2013.39

[P3] D. Sampson and P. Zervas, "Supporting Accessible Technology-Enhanced Training: The eAccess2Learn Framework", IEEE Transactions on Learning Technologies (TLT), vol. 4(4), pp. 353-364, IEEE Computer Society, October 2011

[P4] D. Sampson and P. Zervas, "A Workflow for Learning Objects Lifecycle and Reuse: Towards Evaluating Cost Effective Reuse", Educational Technology & Society Journal, Special Issue on Advanced Learning Technologies, vol. 14(4), pp. 64-76, October 2011

International Conference Papers

[P5] P. Zervas and D. Sampson, "A Quantitative Analysis of the Reuse of Mobile Assisted Language Learning Resources: The Case of Mobile2Learn Repository", in Proc. of the 13th IEEE International Conference on Advanced Learning Technologies (ICALT 2013), Beijing, China, IEEE Computer Society, 15-18 July 2013

[P6] D. Sampson and P. Zervas, "Tools and Services for Open Access to Education and Learning", in 3rd International Conference on e-Learning and Distance Learning (ELI 2013), Riyadh, Saudi Arabia, 4-7, February 2013

[P7] D. Sampson and P. Zervas, "Open Access to Mobile Assisted Language Learning supported by the Mobile2Learn Framework", in Proc. of the 12th IEEE International Conference on Advanced Learning Technologies (ICALT 2012), Rome, Italy, IEEE Computer Society, 4-6, July 2012

[P8] D. Sampson and P. Zervas, "Cost Metrics for Effective Learning Objects Reuse", in Proc. of the 11th IEEE International Conference on Advanced Learning Technologies (ICALT 2011), Athens, Georgia, USA, IEEE Computer Society, 6-8, July 2011

[P9] D. Sampson and P. Zervas, "Technology-enhanced Training for People with Disabilities: The eAccess2Learn Framework", in Proc. of the 2nd International Conference on Intelligent Networking and Collaborative Systems (INCoS 2010), Thessaloniki, Greece, IEEE Computer Society, 24-26, November 2010 [**BEST PAPER AWARD**]

[P10] P. Zervas and D. Sampson, "Enhancing Educational Metadata with Mobile Assisted Language Learning Information", in Proc. of the 10th IEEE International Conference on Advanced Learning Technologies (ICALT 2010), Sousse, Tunisia, IEEE Computer Society, 5-7, July 2010

1 Introduction

1.1 Motivation and Problem Statement

Over the past years, the term Open Educational Resources (OERs) has been emerged, aiming to promote open access to digital educational resources that are available online for everyone at a global level (Caswell et al., 2008). The OER term was introduced by UNESCO (2002), which has defined OERs as the "technology-enabled, open provision of educational resources for consultation, use and adaptation by a community of users for non-commercial purposes". Another widely used definition of OERs has been provided by Atkins et al. (2007), who have defined OERs as: "*full courses, open courseware and content, educational modules, textbooks, streaming videos, tests and assessments, open source software tools, and any other tools and materials used to support teaching or learning*".

In response to this emerging trend several OER initiatives have been developed worldwide by large institutions such as MIT's OpenCourseWare (OCW), Stanford's iTunes and Rice University's Connexions, or by communities (or consortia) such as MERLOT and OER Commons (Ehlers, 2011, Walsh, 2010). The expected benefits of OERs for learners and teachers can be summarized as follows (Geser, 2007): (a) they are free to use and publicly available, (b) they can be used and/or reused in teaching and learning (usually with attribution to the creator), (c) they can be repurposed, that is, modified/adapted for different educational context of use, (d) they can improve teaching by building on other people's work and (e) their development is a global movement and as a result educational communities across borders can be created around them.

As with many emerging terms, there is not a single and consistent definition for OERs. According to the various existing definitions, the OER term is subject to different interpretations such as open educational content, open courseware and open source software (Friesen, 2009). This means that OERs are not limited to open educational content and they can be of different granularity and different formats (Lane & McAndrew, 2010).

Nevertheless, existing OER initiatives do not treat their OERs differently according to their granularity levels and consequently they adopt a flat (non-modular) model for supporting the main stages of a typical e-Learning chain, namely, creation, publication, discovery, acquisition, access, use, reuse and delivery of OERs. The main drawback of this approach is that OERs are treated in a non-modular manner without considering the different levels of granularity (namely, educational content, learning activities, educational courses, education and/or training programmes) and the different tools and services needed to handle the particularities of each granularity level. Therefore, the systematic definition (actions, roles, tools and services) of appropriate hierarchical models that support the main stages of a typical e-Learning chain is an interesting issue in the field of Technology-enhanced Learning (TeL).

On the other hand, Learning Objects (LOs) are a common format for developing and sharing educational content based on modular design but they do not include the notions of openness (Friesen, 2009; Lane & McAndrew, 2010). Within this context it is reasonable to combine OERs with the LO paradigm towards addressing OERs granularity levels and aspects of modular design, which can support OERs repurpose and/or reuse for different educational contexts of use. LOs and their associated metadata are typically organized, classified and stored in web-based repositories which are referred to as Learning Object Repositories (LORs). McGreal (2004) has defined LORs as systems that "*enable users to locate, evaluate and manage learning objects through the use of "metadata," namely, descriptors or tags that systematically describe many aspects of a given learning object, from its technical to its pedagogical characteristics*". LORs are developed aiming to facilitate the enhancement of LOs reuse (Ochoa & Duval, 2008; McGreal, 2008). This is also a challenging issue in the field of TeL, since the design and deployment process of high quality educational content is very expensive, and therefore, any effort to reduce development costs is highly desirable (Zimmermann et al., 2006).

The main hypothesis of this thesis is that it is feasible to construct a hierarchical framework that will be able to support the different granularity levels of OERs, the relationships between these levels and the different tools and services needed to

handle the particularities of each granularity level. Moreover, within this framework LOs reuse can be supported and systematically modelled towards identifying metrics for cost effective LOs reuse. Finally, the proposed framework can be customized for supporting LOs reuse in two different fields of application namely Accessible Technology-enhanced Learning and Mobile Assisted Language Learning.

1.2 Contribution beyond the State of the Art

1.2.1 A Hierarchical Framework for Open Access and Reuse to Education and Learning

The main of aim of this research work was to construct a hierarchical framework (including, hierarchical elements, roles and actions) for supporting the main stages of a typical e-Learning chain, namely, creation, publication, discovery, acquisition, access, use, reuse and delivery of OERs. The framework was defined to support the process of modular design by re-using the hierarchical elements of the framework at different levels.

The results of this research have been published / accepted for publication in the following scientific journal and international conferences:

1. D. Sampson and P. Zervas, "A Hierarchical Framework for Open Access to Education and Learning", International Journal of Web Based Communities, vol. 10(1), pp. 25-51, Inderscience Publishers, January 2014
2. D. Sampson and P. Zervas, "Tools and Services for Open Access to Education and Learning", in 3rd International Conference on e-Learning and Distance Learning (ELI 2013), Riyadh, Saudi Arabia, 4-7, February 2013

1.2.2 A Workflow for Learning Objects Lifecycle and Reuse

The main of aim of this research work was to focus on the lowest hierarchical element of the proposed hierarchical framework (see section 1.2.1) and to investigate the process of LOs reuse. In order to achieve this, we identified the aspects of LOs reuse within the context of learning activities design and development, we proposed a detailed workflow for LOs lifecycle that can support LOs reuse and we defined a set of metrics for cost effective LOs reuse. Finally, we

performed a cost-benefit analysis and we discussed the cost effectiveness conditions of LOs reuse in various use cases.

The results of this research have been published in the following scientific journal and international conferences:

1. D. Sampson and P. Zervas, "A Workflow for Learning Objects Lifecycle and Reuse: Towards Evaluating Cost Effective Reuse", Educational Technology & Society Journal, Special Issue on Advanced Learning Technologies, vol. 14(4), pp. 64-76, October 2011
2. D. Sampson and P. Zervas, "Cost Metrics for Effective Learning Objects Reuse", in Proc. of the 11th IEEE International Conference on Advanced Learning Technologies (ICALT 2011), Athens, Georgia, USA, IEEE Computer Society, 6-8, July 2011

1.2.3 Applying the Proposed Hierarchical Framework for Supporting Open Access and Reuse to Accessible Technology-Enhanced Training

The main objective of this research work was to define an appropriate case study for applying and evaluating the proposed hierarchical framework (see section 1.2.1) towards supporting LOs reuse. The proposed hierarchical model was applied for supporting the main stages of a typical e-Learning chain in the field of Technology-enhanced Training of People with Disabilities (namely, visually impaired and motor disabled people). More specifically, the proposed framework was applied in order to support the creation, publication, discovery, acquisition, access, use and reuse of accessible eTraining resources (in the form of LOs) and accessible eTraining courses.

The results of this research have been published in the following scientific journal and international conferences:

1. D. Sampson and P. Zervas, "Supporting Accessible Technology-Enhanced Training: The eAccess2Learn Framework", IEEE Transactions on Learning Technologies (TLT), vol. 4(4), pp. 353-364, IEEE Computer Society, October 2011
2. D. Sampson and P. Zervas, "Technology-enhanced Training for People with Disabilities: The eAccess2Learn Framework", in Proc. of the 2nd International

Conference on Intelligent Networking and Collaborative Systems (INCoS 2010), Thessaloniki, Greece, IEEE Computer Society, 24-26, November 2010 **[BEST PAPER AWARD]**

1.2.4 Applying the Proposed Hierarchical Framework for Supporting Open Access and Reuse to Mobile Assisted Language Learning

The main objective of this research work was to define an additional case study for applying and evaluating the proposed hierarchical framework (see section 1.2.1) towards supporting LOs reuse. The proposed hierarchical model was also applied for supporting the main stages of a typical e-Learning chain in the field of Mobile Assisted Language Learning (MALL). More specifically, the proposed framework was applied in order to support the creation, publication, discovery, acquisition, access, use and reuse of MALL resources (in the form of LOs) and MALL courses.

The results of this research have been published / accepted for publication in the following scientific journal and international conferences:

1. P. Zervas and D. Sampson, "Facilitating Teachers' Reuse of Mobile Assisted Language Learning Resources using Educational Metadata", IEEE Transactions on Learning Technologies, IEEE Computer Society, (in press), http://dx.doi.org/10.1109/TLT.2013.39

2. P. Zervas and D. Sampson, "A Quantitative Analysis of the Reuse of Mobile Assisted Language Learning Resources: The Case of Mobile2Learn Repository", in Proc. of the 13th IEEE International Conference on Advanced Learning Technologies (ICALT 2013), Beijing, China, IEEE Computer Society, 15-18 July 2013

3. D. Sampson and P. Zervas, "Open Access to Mobile Assisted Language Learning supported by the Mobile2Learn Framework", in Proc. of the 12th IEEE International Conference on Advanced Learning Technologies (ICALT 2012), Rome, Italy, IEEE Computer Society, 4-6, July 2012

4. P. Zervas and D. Sampson, "Enhancing Educational Metadata with Mobile Assisted Language Learning Information", in Proc. of the 10th IEEE

International Conference on Advanced Learning Technologies (ICALT 2010), Sousse, Tunisia, IEEE Computer Society, 5-7, July 2010

1.3 Thesis Overview

This dissertation consists of six chapters, as follows:

In chapter 1, we outline the PhD thesis motivation, problem statement and contributions.

In chapter 2, we discuss Open Educational Resources (OERs) and their connection with Learning Objects (LOs) and Learning Designs (LDs), as well as their web-based management through Learning Object Repositories (LORs) and Learning Design Repositories (LDRs). Next, we describe the elements and the main user roles of our proposed hierarchical framework for open access to education and learning. Then, we present a set of tools that support the proposed framework and empower the main user roles previously indentified. Finally, we discuss the conclusions that can be offered.

In chapter 3, we study existing efforts for the definition of the different steps involved during the LOs lifecycle that can support LOs reuse and we identify their limitations. Based on the discussion of existing proposals, we propose a thorough workflow for LOs lifecycle that can support LOs reuse within the context of learning activities design and development. Finally, we use the proposed LOs lifecycle workflow to define a set of metrics so as to measure the cost effectiveness of LOs reuse and we extract recommendations that can facilitate interested parties to take more informed decisions about the potential benefits of LOs reuse.

In chapter 4, we discuss the issue of accessibility in Technology-Enhanced Training and we present the current initiatives and approaches on enhancing accessibility in technology-enhanced training systems. Next, we describe the customization and extension of the proposed hierarchical framework presented in chapter 2 for facilitating design and production of accessible eTraining Resources and Courses that can be interoperable between different eTraining Platforms and Systems and we present the tools and services of the customized hierarchical framework. Finally, we present experiments for evaluating the customized hierarchical framework within

the context of designing and developing accessible eTraining Resources and Courses for two (2) disabled user groups, namely, low vision and motor disabled people.

In chapter 5, we discuss existing efforts in the area of OERs for supporting open access and reuse of MALL resources and we identify the limitations of current practices. Next, we describe the customization and extension of the proposed hierarchical framework presented in chapter 2 for facilitating open access and reuse to MALL resources within the context of MALL courses design and development and we present the tools of the proposed framework with emphasis on the educational metadata aspects of the framework. Afterwards, we conduct a quantitative analysis of the reuse of MALL resources within MALL courses developed with the customized hierarchical framework tools and we discuss the results of our study.

Finally, in chapter 6 we present the conclusions of the research work conducted in this thesis and we indicate directions for future research.

2 A Hierarchical Framework for Open Access to Education and Learning[5]

2.1 Introduction

In this chapter, we propose a hierarchical open access framework that considers different hierarchical elements for supporting the main stages of a typical e-Learning chain and we present a set of tools that support this framework.

The chapter is structured as follows: First, we discuss Open Educational Resources (OERs) and their connection with Learning Objects (LOs) and Learning Designs (LDs), as well as their web-based management through Learning Object Repositories (LORs) and Learning Design Repositories (LDRs). Next, we describe the elements and the main user roles of our proposed hierarchical open access to education and learning framework. Then, we present a set of tools that support the proposed framework and empower the main user roles previously indentified within the e-Learning chain. Finally, we discuss the conclusions that can be offered.

2.2 Background

2.2.1 Open Educational Resources and Learning Objects

The OER term was introduced by UNESCO (2002), which has defined OERs as the "technology-enabled, open provision of educational resources for consultation, use and adaptation by a community of users for non-commercial purposes". Another widely used definition of OERs has been provided by Atkins et al. (2007), who have defined OERs as: "*full courses, open courseware and content, educational modules, textbooks, streaming videos, tests and assessments, open source software tools, and any other tools and materials used to support teaching or learning*" (Atkins et al., 2007). According to Geser (2007) OERs have three core features: (a) they are available for open and free of charge access by educational institutions and end-users such as teachers and students, (b) they are licensed for reuse, free from

[5] This chapter is an adapted copy of the following published journal paper:

D. Sampson and P. Zervas, "A Hierarchical Framework for Open Access to Education and Learning", International Journal of Web Based Communities, vol. 10(1), pp. 25-51, Inderscience Publishers, January 2014

restrictions to modify, combine and repurpose, as well as they are designed for easy reuse in open content standards and formats, and (c) with regard to software tools, their source code is open and licensed for reuse.

On the other hand, Learning Objects (LOs) are a common format for developing and sharing educational content and they have been defined by Wiley (2002) as: "*any type of digital resource that can be reused to support learning*". More specifically, LOs include: "video and audio lectures (podcasts), references and readings, workbooks and textbooks, multimedia animations, simulations, experiments and demonstrations, as well as teachers' guides and lesson plans" (McGreal, 2008). Thus, one can claim that OERs are related to LOs assuming open access licensing (Friesen, 2009; Lane & McAndrew, 2010).

OERs' definitions do not explicitly include the notion of modular design, whereas LOs do not include notions of openness (Friesen, 2009). Both consider sharing and reuse but LOs appear to acknowledge the intellectual property rights of the content developers and be more commercially minded, whereas many OERs are explicitly released under a non-commercial use license (Lane & McAndrew, 2010).

2.2.2 From Learning Object Repositories to Learning Design Repositories

LOs and their associated metadata are typically organized, classified and stored in web-based repositories which are referred to as Learning Object Repositories (LORs). McGreal (2004) has defined LORs as systems that "*enable users to locate, evaluate and manage learning objects through the use of "metadata," namely, descriptors or tags that systematically describe many aspects of a given learning object, from its technical to its pedagogical characteristics*". Most of the LORs that have been developed worldwide adopt the IEEE LOM standard (IEEE LTSC, 2005) or an application profile of IEEE LOM (Smith et al. 2006) for describing their LOs aiming to facilitate search and retrieval of them among different LORs (McGreal, 2008).

Nevertheless, in most cases LORs include limited explicit information about their hosted LOs' learning context of use (Conole, 2007; Bailey et al., 2006). Learning context can be described by the elements of a particular learning design (such as the learning objectives, the pedagogical strategy, the learning activities, the participating

roles and the tools and services) and the elements of the individual learner's profile (such as the competence profile and the semi-permanent personal characteristics) (Sampson & Zervas, 2012a). Moreover, it has been identified that teachers would benefit from: (a) having access to best teaching practices, (b) sharing their teaching practices with other teachers, and (c) reflecting on others teaching practices (Galley et al., 2010; Conole, 2008). This has the potential to provide learning and educational contextual knowledge to LOs available in LORs. For this purpose, there are international efforts for designing and developing web-based repositories of learning designs (LDs), assuming that a learning design can offer an explicit description of the pedagogical context of use where all key design parameters (namely, educational objectives, pedagogical model, participating roles and tools and services) are formally described (Paquette et al., 2008).

A Learning Design (LD) is defined as: "*the description of the teaching-learning process, which follows a specific pedagogical model or practice that takes place in a unit of learning (eg, a course, a learning activity or any other designed learning event) towards addressing specific learning objectives, for a specific target group in a specific context or subject domain*" (Koper & Olivier, 2004). As it become evident from the aforementioned definition, a LD includes information that contributes towards the definition of learning and educational context of use for the LOs.

Similar to LOs, Learning Designs (LDs) can be organized, classified and stored in web-based repositories which are referred to as Learning Design Repositories (LDRs). LDRs are built so as to support storage, discovery, retrieval, use, reuse and sharing of LDs and LD Templates among educational communities (Griffiths et al., 2005; Wilson, 2005). A LD Template is a LD without specific educational content (Griffiths et al., 2005). One way that provides a standard notation language for the description of LDs and LD Templates is the IMS Learning Design (LD) Specification (IMS GLC, 2003a) and many of the existing LDRs adopt this specification for describing their LDs and LD Templates aiming to facilitate inter-exchange of them among different LDRs.

2.3 The Proposed Hierarchical Framework

In this section, we propose a hierarchical framework, which aims to support the main stages of a typical e-Learning chain namely, creation, publication, discovery, acquisition, access, use, reuse and delivery of OERs. Next, we present in details the elements and the participating user roles of the proposed hierarchical framework.

2.3.1 Hierarchical Elements

The proposed hierarchical framework identifies four (4) basic hierarchical elements (see Figure 2.1), which are presented below:

- **Educational Content:** This is the lowest level of the hierarchical open access framework and it includes: (a) Open Educational Resources (OERs) in the form of Learning Objects (LOs), and (b) educational metadata that are used to describe the different educational characteristics and attributes of a LO (Currier, 2008).
- **Learning Activities:** This is the second level of the hierarchical open access framework and for the purpose of our work, a Learning Activity (LA) is defined as: "*the interaction of learner(s) with other(s) (peers and/or tutors) and with a learning environment (optionally involving educational content, tools and services), which emerges as a result of performing a task following a specific pedagogical strategy in order to achieve one or more learning objectives*" (Beetham, 2007).
- **Educational Courses:** This is the third level of the hierarchical open access framework and it can be developed as a sequence of LAs following a specific pedagogical strategy (Alonso et al., 2005). Moreover, for the purpose of our work we consider that an educational course is delivered entirely online through desktop and/or mobile devices.
- **Education and/or Training Programs:** This is the highest level of the hierarchical open access framework and it can be developed as a synthesis of educational courses. An education and/or training program typically includes the educational courses that constitute it, as well as the virtual classrooms that are used for supporting the delivery of the educational courses (Daniels, 2009).

As we can notice from the description of the elements of the proposed hierarchical framework, there is a clear relationship between the different hierarchical elements. Furthermore each hierarchical element consists of a composition of instances of lower level elements. More specifically, (a) LAs are designed and developed based on previously developed educational content in the form of LOs, (b) educational courses are designed and developed based on previously designed LAs and (c) education and/or training programs are designed and developed based on previously designed educational courses.

2.3.2 User Roles

The main user roles (see Figure 2.1) that are identified within the proposed open access hierarchical framework are the following:

- **Educational Content Suppliers:** this is the user role responsible for designing and developing independent open educational resources in the form of LOs. The Educational Content Suppliers need to be able to characterize their newly developed LOs with educational metadata and offer them to existing Learning Object Repositories (LORs) for sharing and reuse by instructional designers and/or teachers. The proposed open access framework provides them with the technological means for tagging their LOs with appropriate educational metadata.
- **Instructional Designers:** They define learning objectives and they design appropriate LAs and educational courses that can lead to the accomplishment of these objectives. They are responsible (a) for designing LAs by selecting: (i) appropriate LOs (previously developed by educational content suppliers and/or teachers), (ii) appropriate tools and services that support the LAs and (iii) appropriate roles that participate to the LAs following a specific pedagogical strategy and (b) for designing educational courses, following a specific pedagogical strategy, by sequencing appropriate LAs (previously developed by them or by other instructional designers and/or teachers). Both LAs and educational courses should be represented in a common machine understandable format for offering them through existing Learning Design Repositories (LDRs) for sharing and reuse by other

instructional designers, teachers and/or e-Learning services providers. Thus, the proposed open access hierarchical framework provides Instructional Designers with the technological means for (a) searching and selecting LOs, and (b) designing and developing Learning Activities and Educational Courses.

- **E-Learning Services Providers**: this is the user role responsible for delivering education and/or training programs as a synthesis of appropriate educational courses (previously designed by Instructional Designers and/or teachers). The proposed open access hierarchical framework provides them with the technological means to deliver Education and/or Training programs, as well as individual Educational Courses to Learners.
- **Teachers:** Their role is threefold. More specifically, teachers can design and develop new LOs to support their learning activities, possibly describe them with educational metadata and offer them to a LOR for future use by other instructional designers and/or teachers. They can design and develop LAs by selecting: (i) appropriate LOs, (ii) appropriate tools and services that support the LAs and (iii) appropriate roles that participate to the LAs following a specific pedagogical strategy and educational courses by sequencing appropriate LAs following a specific pedagogical strategy and offer them to a LDR for future use by other instructional designers and/or teachers. Finally, they can participate to educational courses and education and/or training programs, so as to support learners in the attainment of their learning objectives.
- **Learners:** These are the final users of the educational courses and the main participants in education and/or training programs. Thus, the proposed hierarchical open access framework provides them with the technological means to participate in education and/or training programs, as well as to individual educational courses through desktop and/or mobile devices.

Figure 2.1 presents the identified hierarchical elements and user roles, as well as, their needs and interconnections within the proposed open access hierarchical framework.

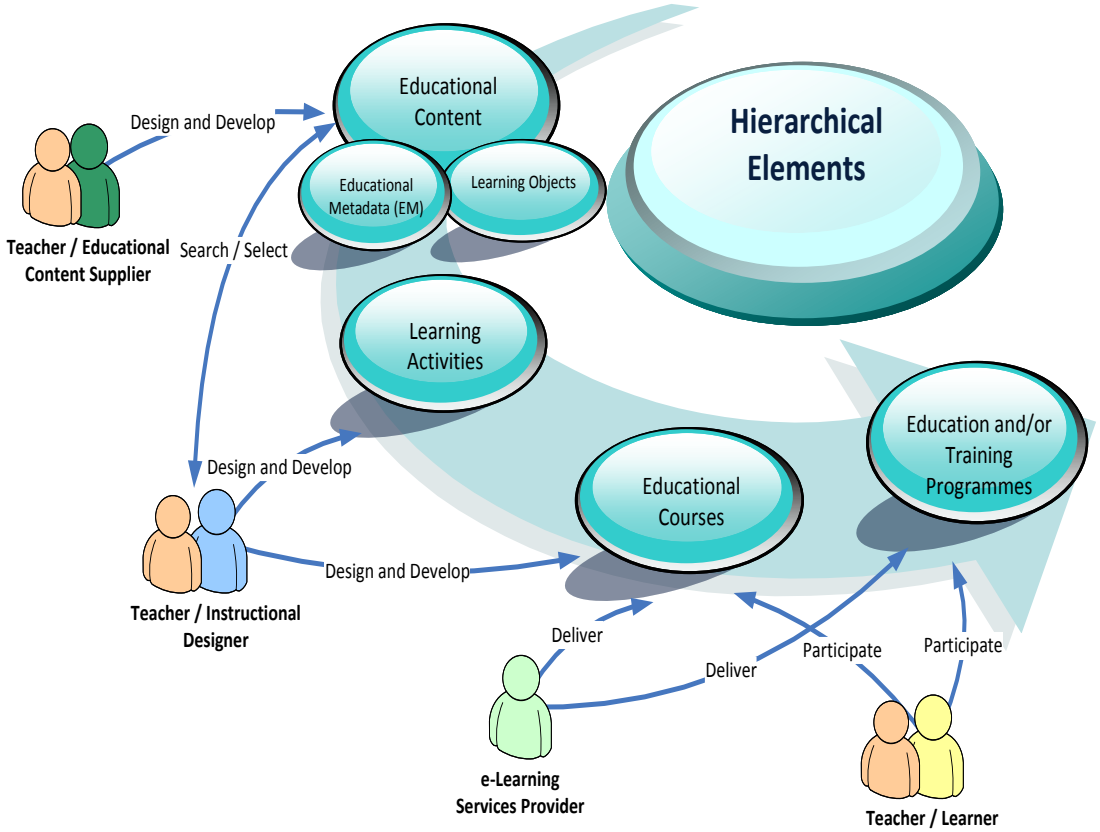


Figure 2.1: Hierarchical Elements and Main User Roles of the Open Access Hierarchical Framework

2.3.3 Tools for Supporting the Proposed Framework

The proposed open access hierarchical framework is supported by a set of tools that aim to address the needs of the main user roles identified in section 2.3.2. Next, we describe these tools in details.

2.3.3.1 The ASK Learning Objects Metadata Authoring Toolkit 2.0 (ASK-LOM-AT 2.0)

ASK Learning Objects Metadata Authoring Toolkit 2.0 (ASK-LOM-AT 2.0) is an open source web-based tool that facilitates the educational content suppliers, the instructional designers and/or the teachers in authoring educational metadata for their LOs, LAs and educational courses, as well as, in organizing and offering them through existing LORs and LDRs. More precisely, the tool provides educational content suppliers, instructional designers and teachers with an authoring environment for describing their LOs, LAs and educational courses with educational metadata conformant with IEEE Learning Objects Metadata (LOM) standard (IEEE

LTSC, 2005). These LOs, LAs and educational courses can then be uploaded to existing LORs and LDRs along with their educational metadata for future use and reuse by other instructional designers and/or the teachers during the process of designing and developing new courses.

The main functionalities of ASK-LOM-AT 2.0 include (Sampson et al., 2011a):

- Educational metadata authoring by using a step-by-step wizard (as presented in Figure 2.2) or by using a single web-form (as presented in Figure 2.3). More specifically, Figure 2.2 presents the step of the wizard where the user fills metadata for the educational category of the IEEE LOM standard, whereas Figure 2.3 presents the process of authoring metadata for all metadata categories of the IEEE LOM standard by using a single web-form.
- Browse and preview existing metadata records that have been authored by other users of the tool.
- Browse and edit metadata records that a specific user has previously authored and stored in the tool metadata repository.
- Import and edit metadata records in XML format following the IEEE LOM standard.
- Export metadata records in XML format following the IEEE LOM standard and import them to existing LORs.

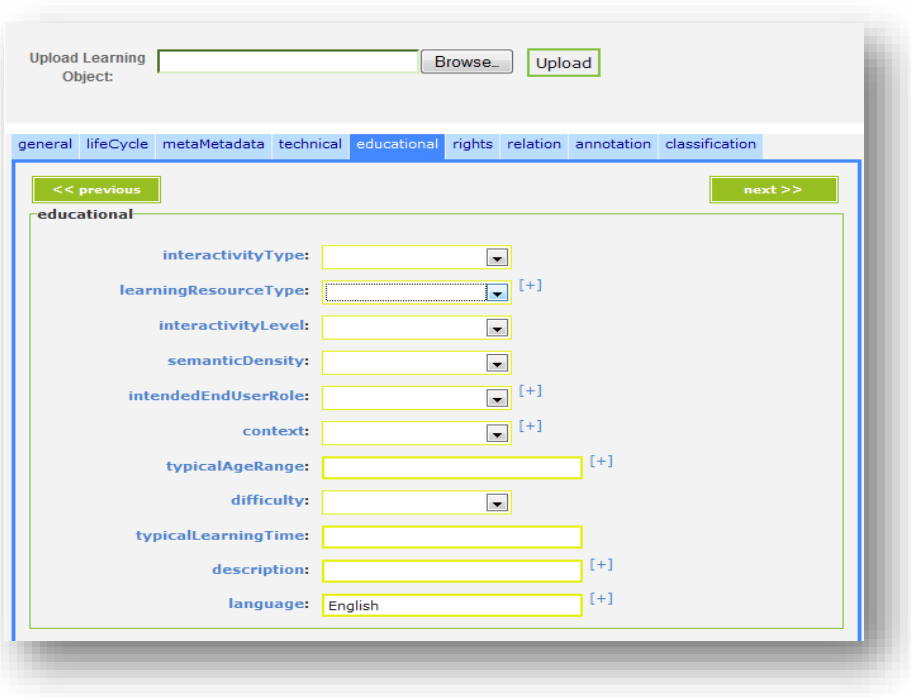


Figure 2.2: Educational metadata authoring through a step-by-step wizard

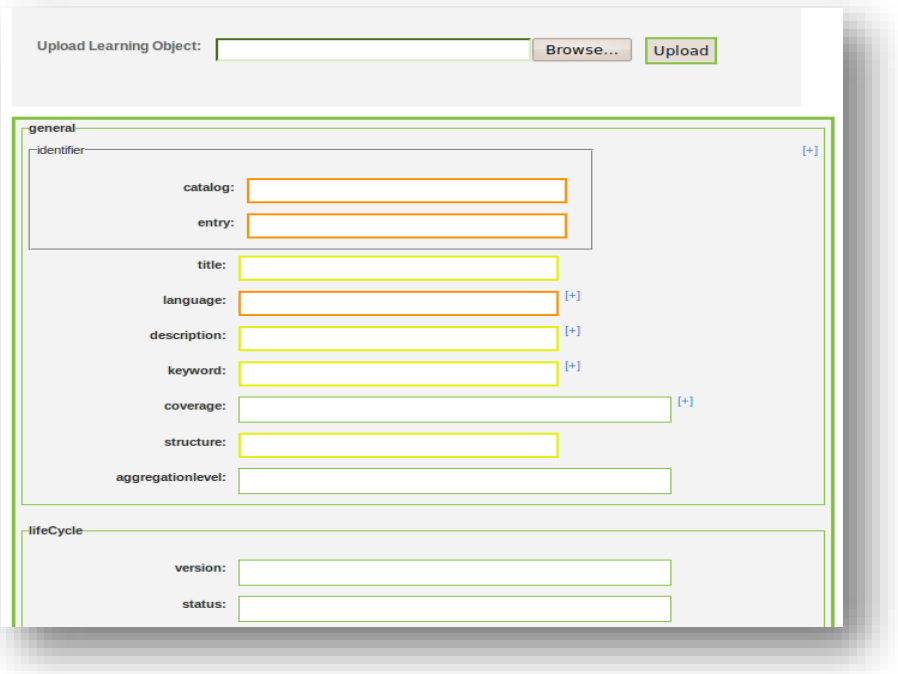


Figure 2.3: Educational metadata authoring through a single page web-form

2.3.3.2 The ASK Learning Objects Metadata Application Profiling Toolkit (ASK-LOM-AP)

ASK Learning Objects Metadata Application Profiling Toolkit (ASK-LOM-AP) is an open source web-based tool that facilitates educational content suppliers to develop and manage Application Profiles (APs) of the IEEE LOM standard. An Application Profile (AP) is a metadata scheme, which consists of metadata elements selected from one or more standard metadata schemes combined in a compound schema. The purpose of an Application Profile is to adapt or combine existing schemas into a package that is tailored to the functional requirements of a particular application, while retaining interoperability with the original base schemas (Smith et al., 2006).

The main functionalities of the ASK-LOM-AP include (Sampson et al., 2012):

- The development and management of new IEEE LOM APs by using a step-by-step wizard (as presented in Figure 2.4) conformant with guidelines from International Organizations such as IMS Global Learning Consortium and European Committee for Standardization (CEN/ISSS).
- The export of the XML Schema of a developed IEEE LOM AP with all the modifications, in accordance with the base schema of the IEEE LOM Standard (as presented in Figure 2.5). More specifically, Figure 2.5 presents the machine readable representation (XSD file) of a developed IEEE LOM AP with ASK-LOM-AP. Finally, the produced IEEE LOM APs can be imported to ASK-LOM-AT 2.0, which was described in section 2.3.3.1 and support authoring of educational metadata based on these IEEE LOM APs.

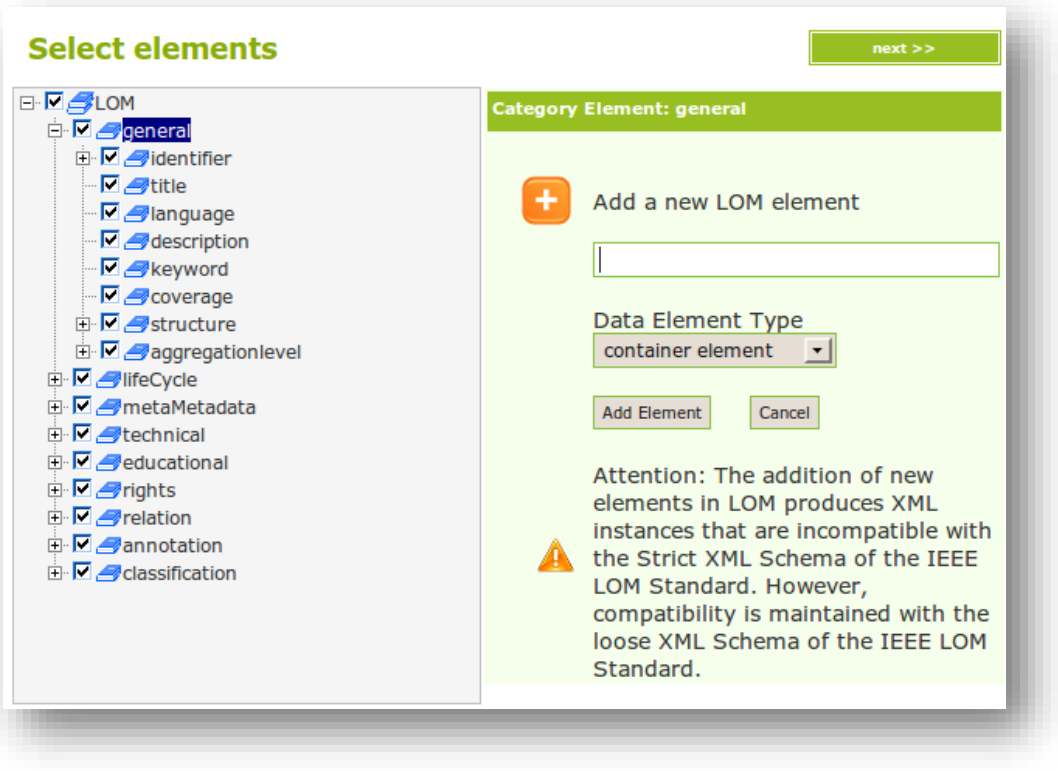


Figure 2.4: Development of a new IEEE LOM Application Profile using a step-by-step wizard

Figure 2.5: Export the Developed IEEE LOM Application Profile as an XML Schema

2.3.3.3 The ASK Learning Objects Social Tagging Toolkit 2.0 (ASK-LOST 2.0)

ASK Learning Objects Social Tagging Toolkit 2.0 (ASK-LOST 2.0) is an open source web-based tool that facilitates instructional designers and/or teachers to add tags to LOs, LAs and educational courses that are stored in LORs and LDRs exploiting social tagging. Social tagging refers to the process of adding keywords, also known as tags, to any type of digital resource by users (rather than resources' authors) (Vossen & Hagemann, 2007). Social tagging has emerged in educational applications encouraging individuals to tag LOs, LAs and educational courses and openly share their tags with other users towards facilitating search and retrieval of already used and known LOs, LAs and educational courses by using meaningful terms (Dahl & Vossen, 2008). It offers a unique and personalized way of classification delivered by users' tags and not by an externally defined classification system. Additionally, tags generated by large web-based educational communities bare the potential to discern contextual information from tags' aggregation, facilitating an educational wisdom of the crowd. Finally, social tagging can enable the formation of web-based communities around educational tags. These networks can reflect the interests and expertise of users contributing to the tag development (Vuorikari et al., 2010).

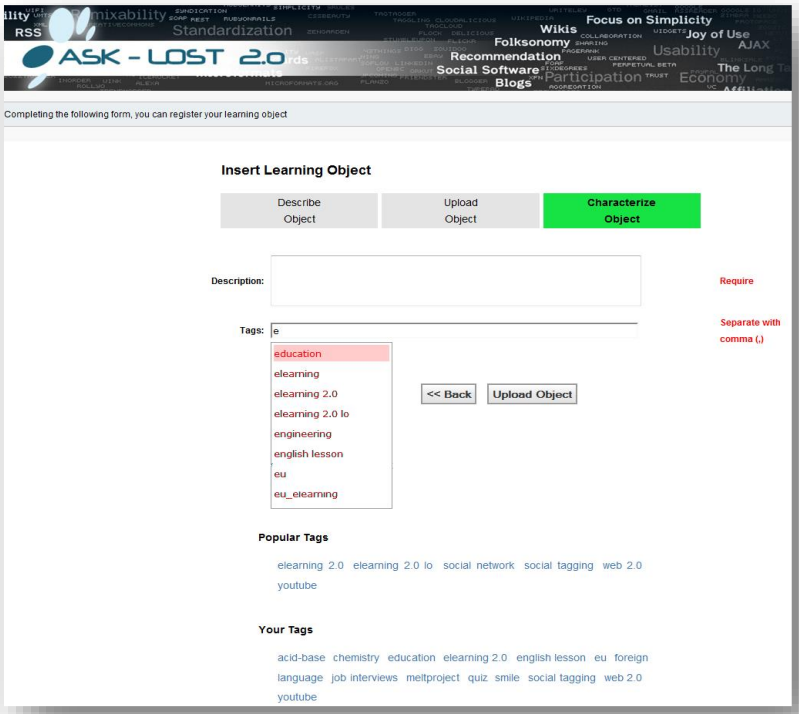


Figure 2.6: The process of guided and auto-suggested tagging

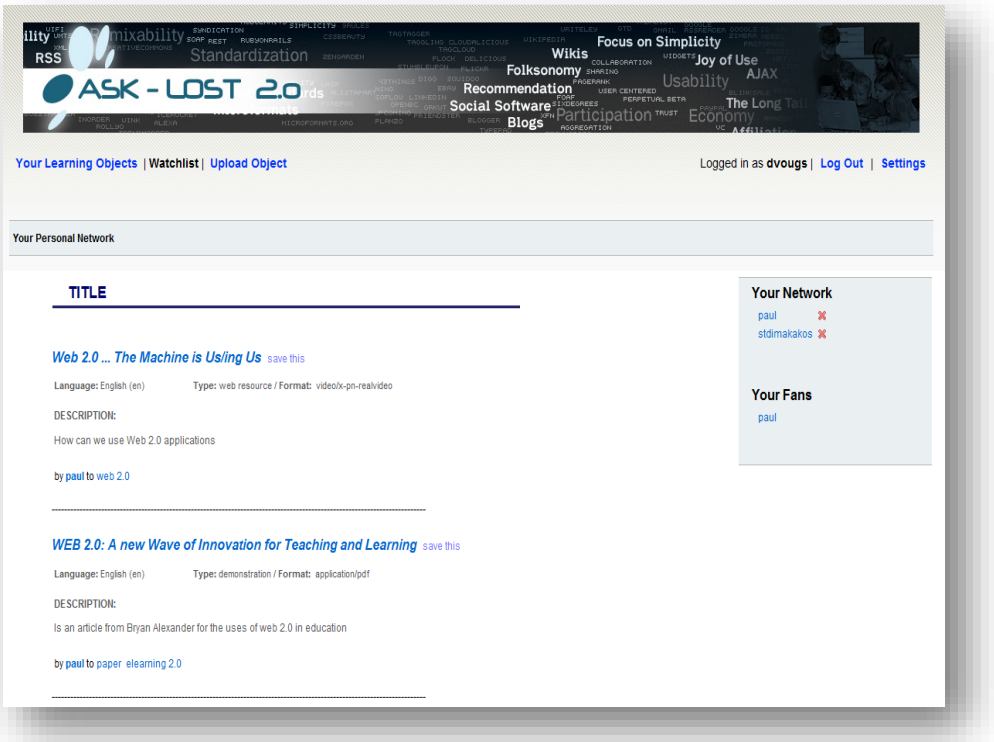


Figure 2.7: Presentation of a user's personal network

The main functionalities of ASK–LOST 2.0 include (Sampson et al., 2011b):

- **Guided tagging** (as presented in Figure 2.6), where the user is presented with his/her tags previously used for characterizing other digital educational resources (referred to as Personal Tags), as well as, with tags that are most frequently used by other users regarding this specific LO, LA or educational course (referred to as Popular Tags). Figure 2.6 presents the process of facilitating the user to tag digital educational resources by presenting him/her previously used tags (at the bottom of the page) by himself/herself and by other users.
- **Auto-suggested tagging** (as presented in Figure 2.6), where the user is presented with suggested tags that have been used by other users and are relevant with the tag that the user is typing.
- **Creation of user's personal collection**, where he/she has the capability to save to his/her personal list, LOs, LAs or educational courses uploaded by other users and browse the tags that these users have used.
- **Browsing via tag cloud**, where the user can search and browse LOs, LAs or educational courses using an appropriately formatted tag cloud produced by the tags that all users of the tool have offered.
- **Web-based communities support** (as presented in Figure 2.7), where the user can create watchlists, which include other users' profiles, so as to be able to monitor (through RSS feeds) the tags that these users are using, as well as the LOs, LAs or educational courses that they are submitting to the repository of the tool. Figure 2.7 presents the personal network of a user including the names of the users, as well as the digital educational resources that they have previously tagged.

2.3.3.4 The ASK Learning Design Toolkit (ASK-LDT)

ASK Learning Design Toolkit (ASK-LDT) is a stand-alone tool that enables instructional designers and/or teachers (a) to express their pedagogical strategies, in the form of LD templates, using a common machine understandable way, and (b) to design and develop educational courses using a reference set of pre-defined LD templates. As a result, a set of LD templates, which are following different pedagogical strategies, can be designed to facilitate the development of educational courses that adopt

these strategies. Moreover, ASK-LDT uses empty of educational resources LD templates to populate them with LOs (tagged with metadata) and produces educational courses as a workflow of learning activities populated with these LOs. More specifically, the main functionalities of ASK-LDT include (Sampson et al., 2005):

- **Development of new educational courses** based on pre-defined LD templates using a graphical interface (as presented in Figure 2.8). Figure 2.8 presents the process of developing a new educational course by interconnecting LAs, which are performed by different roles with the support of different learning tools and services.
- **Characterization of LAs** of an Educational Course by using a common vocabulary of terms based on "Dialog Plus Learning Activities Taxonomy" (LADiE, 2006) (as presented in Figure 2.9). Figure 2.9 presents the process of characterizing a LA according to the different elements that have been proposed by the "Dialog Plus Learning Activities Taxonomy".
- **Populating with LOs** (html pages, images, videos etc.) the LAs of an educational course or changing the existing ones.
- **Save educational courses** as Packages (zip format) conformant with IMS Learning Design Specification (IMS GLC, 2003a), and share them through existing LDRs.

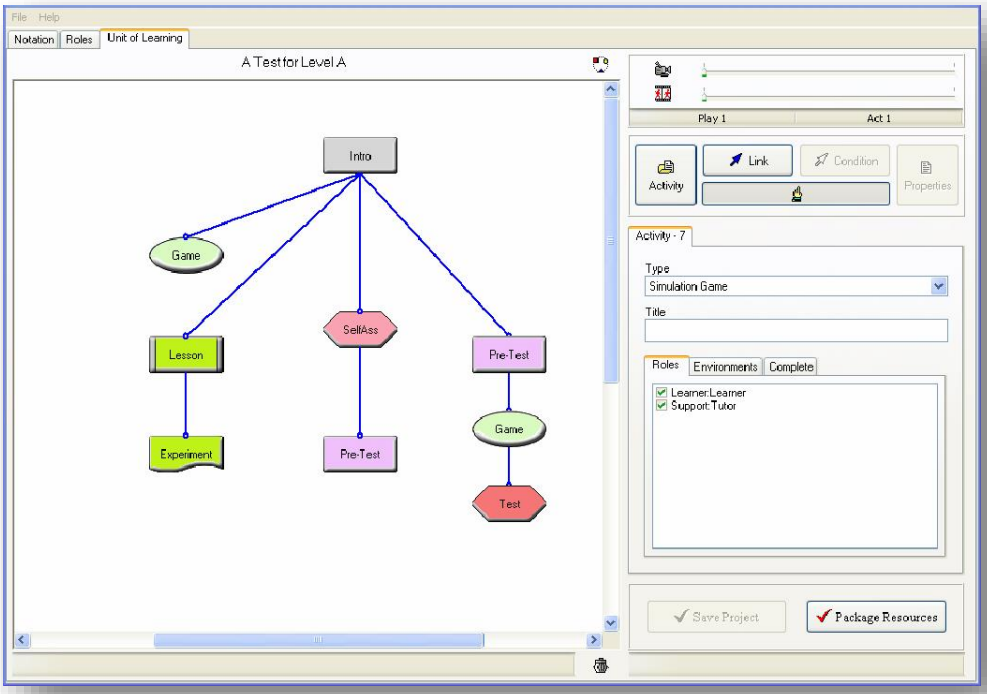


Figure 2.8: Developing a new Educational Course based on an existing learning design template

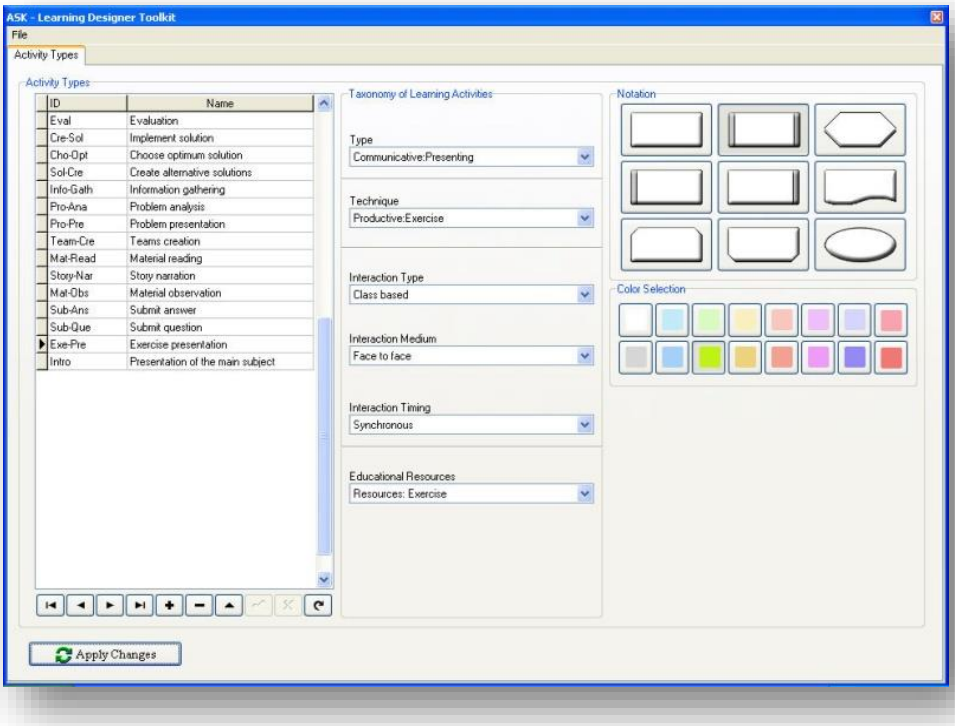


Figure 2.9: Characterization of the Educational Course's learning activities

2.3.3.5 The ASK Mobile Learning Design Player (ASK-Mobile-LD-Player)

ASK Mobile Learning Design Player (ASK-Mobile-LD-Player) is a stand-alone tool suitable for smart phone devices with windows mobile or android operating system that facilitates e-Learning Services Providers to deliver educational courses that have been retrieved from an existing LDR and they are conformant with the IMS Learning Design Specification (IMS GLC, 2003a). More specifically, the main functionalities of ASK-Mobile-LD-Player include (Zervas & Sampson, 2014; Sampson et al., 2007):

- **Enrolment of multiple roles/actors** such as individual learners, groups of learners and teachers (as presented in Figure 2.10), enabling the formation of web-based communities around educational courses.
- **Navigation to the LAs of an educational course** using a graphical interface (as presented in Figure 2.11), and (c) rendering of HTML-based educational content and flash files (as presented in Figure 2.12).

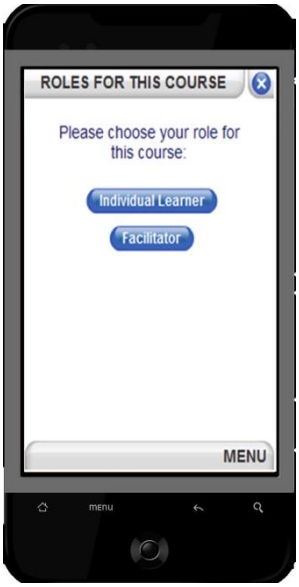


Figure 2.10: Selecting a role for participating to an Educational Course

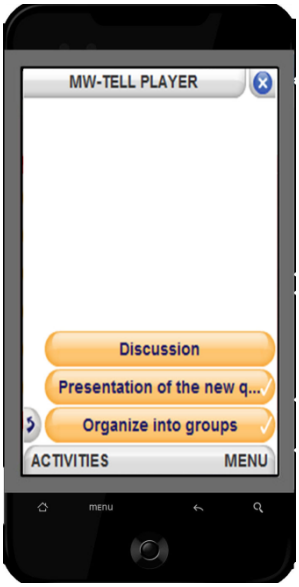


Figure 2.11: Navigating to the next learning activity of an Educational Course

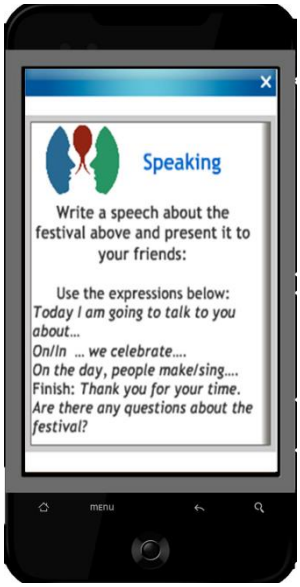


Figure 2.12: Rendering LOs of the Learning Activities of an Educational Course

2.3.3.6 The ASK Mobile SCORM Player

ASK Mobile SCORM Player is a stand-alone tool suitable for smart phone devices with android operating system that facilitates e-Learning Services Providers to

deliver educational courses which are conformant with Sharable Content Object Reference Model (SCORM) (Dodds & Thropp, 2006) and have been retrieved from an existing LDR.

More specifically, the main functionalities of ASK Mobile SCORM Player include (Zervas & Sampson, 2014):

- **Import and deliver educational courses** conformant with SCORM 2004 to learners' mobile devices (as presented in Figure 2.13).
- **Sequencing and navigation** to the learning activities of an Educational Course based on learner's choices and achievements during run-time (as presented in Figure 2.14).
- **Rendering** of HTML-based educational content and flash files (as presented in Figure 2.15).

Figure 2.13: Import an Educational Course

Figure 2.14: Navigating to next or previous learning activity

Figure 2.15: Rendering LOs of the Learning Activities of an Educational Course

2.3.3.7 The ASK Mobile Moodle

ASK Mobile Moodle is a customization of a widely used existing Course Management System, namely, the Moodle (http://moodle.org/). Course Management Systems

(CMSs) are software applications providing a convenient way to organize and deliver education and/or training programs. More specifically, CMSs enable efficient planning, implementation, administration, tracking and reporting of education and/or training programs (Weller, 2007). ASK Mobile Moodle has been customized following the W3C Mobile Web Best Practices 1.0 (Rabin & McCathieNevile, 2008), so as to be accessible via mobile devices. ASK Mobile Moodle facilitates e-Learning Services Providers to deliver education and/or training Programs to learners' mobile devices. More specifically, ASK Mobile Moodle facilitates (Sampson & Zervas, 2012b):

- **Learners to access Moodle** via any type of mobile device.
- **Learners to enrol in and attend educational courses** via their mobile device (as presented in Figure 2.16), check for new educational courses' material (as presented in Figure 2.17), upload assignments, send questions to their teachers and support the formation of web-based educational communities with the participation of their classmates and their teachers via discussion forums (as presented in Figure 2.18).
- **Teachers to conduct basic educational course's management tasks** via their mobile device such as: monitor their learners' progress, identify and download newly uploaded learners' assignments, answer learners' questions and communicate with their learners through discussion forums (as presented in Figure 2.18).

Figure 2.16: Enrol in and attend an Educational Course

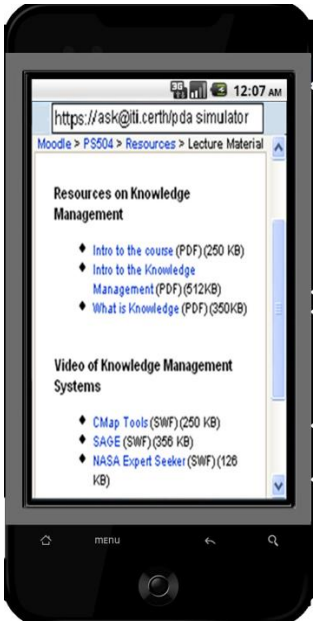


Figure 2.17: Check for new Educational Courses' material

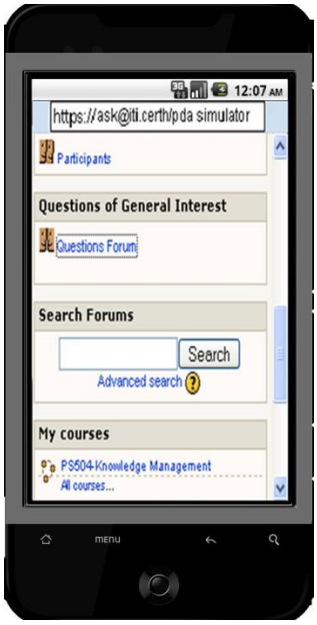


Figure 2.18: Participating to a discussion forum

2.4 Conclusions

Within the landscape of the emerging OER paradigm, it has been identified that existing initiatives do not pay special attention to the different granularity levels of OERs and as a result they adopt a flat model (without granularity levels) for supporting the main stages of a typical e-Learning chain, namely, creation, publication, discovery, acquisition, access, use, reuse and delivery of OERs.

In this chapter, in order to deal with the different levels of granularity in OERs (namely, educational content, learning activities, educational courses, education and/or training programs), the relationships between the different granularity levels and the different tools needed to handle the particularities of each granularity level, we proposed a hierarchical open access framework, so as to support the main stages of a typical e-Learning chain. In this framework, we identified the main user roles and we presented a set of tools, which empower them within the various stages of a typical e-Learning chain. Within the proposed framework, we can identify also a set of important challenges, as follows:

- *Intellectual property and copyright issues:* before publishing LOs, LAs and educational courses that make use of third-party materials on existing LORs and/or LDRs, the authors and/or the publishers, must ensure that they have the right to use these materials. This challenge can be addressed by following Creative Commons (http://creativecommons.org/) licenses when educational content suppliers, instructional designers and teachers are developing LOs, LAs and educational courses.
- *Quality issues:* Finding quality LOs, LAs and educational courses within the proposed framework for open education and learning is an important challenge. This challenge can be addressed either by following a peer review approach, which is a top-down approach and could guarantee the quality of LOs, LAs and educational courses available to existing LORs and LDRs or by following open users review approach, which is a bottom-up approach letting individual users to decide on whether a LO, a LA or an educational course is of high quality, useful or good.
- *Assessment and accreditation issues:* Recognition and accreditation within the proposed framework for open education and learning could also be a challenging issue. This challenge could be addressed by considering assessment on demand, where learners have access to different OERs at different granularity levels, as well as to volunteer teachers and they can be awarded degrees by institutions that are supporting OER initiatives.

In the next chapter, we focus on the lowest hierarchical element of the proposed hierarchical framework and we investigate the process of LOs reuse within the context of LAs design and development.

3 A Workflow for Learning Objects Lifecycle and Reuse[6]

3.1 Introduction

In this chapter, we focus on the lowest hierarchical element of the proposed hierarchical framework and we investigate the process of LOs reuse within the context of LAs design and development.

The chapter is structured as follows: First, we study existing efforts for the definition of the different steps involved during the LOs lifecycle that can support LOs reuse and we identify their limitations. Based on the discussion of existing proposals, we propose a thorough workflow for LOs lifecycle that can support LOs reuse within the context of learning activities design and development. Finally, we use the proposed LOs lifecycle workflow to define a set of metrics so as to measure the cost effectiveness of LOs reuse and we extract recommendations that can facilitate interested parties to take more informed decisions about the potential benefits of LOs reuse.

3.2 Learning Object Lifecycle and Reuse

3.2.1 Learning Objects Reuse: Definition

The main arguments in favor of LOs reuse are twofold. On one hand, LO reuse is highlighted due to the anticipation of cost reductions in the design and development of educational resources while maintaining quality. This is based on the assumption that the more times a LO is reused in different learning settings the more cost effective that LO becomes. On the other hand, LO reuse can be an indicator for a high quality education resource. This is under the assumption that the more a LO is reused the more likely it is to be of high quality as more teachers and/or learners will have the opportunity to interact with it and provide feedback on its use and quality. However, despite the importance of the concept of LOs reuse, the Technology-enhanced Learning (TeL) community has not agreed to a commonly accepted

[6] This chapter is an adapted copy of the following published journal paper:

D. Sampson and P. Zervas, "A Workflow for Learning Objects Lifecycle and Reuse: Towards Evaluating Cost Effective Reuse", Educational Technology & Society Journal, Special Issue on Advanced Learning Technologies, vol. 14(4), pp. 64-76, October 2011

definition of the term 'reuse' resulting to multiple interpretations. The concept of LOs reuse, just as the concept of LOs, is presented in LOs literature in different ways as shown in Table 3-1.

Table 3-1: LOs Reuse Definitions

Authors	Definitions
Wiley (2002, p. 12)	*"LOs can be used over and over again in similar contexts or in domains other than those for which they were designed".*
Polsani (2003, p. 4)	*"A LO is predisposed to be reused in multiple instructional contexts".*
Palmer & Richardson (2004, p. 5)	*"Reuse is the extent to which a LO can operate effectively for a variety of users in a variety of learning contexts over time in order to achieve the same or a different objective from that envisaged by its supplier".*
Rensing et al. (2005, p. 4), Zimmermann et al. (2007, p. 49)	*"Reuse of LOs is any kind of use of existing LOs which are already used in a certain context for teaching or learning by trainers or learners in a new context to serve the same or a new purpose".*
Colossus (2005, p. 1)	*"To reuse the LO with a different group of learners for which the LO was originally created".*
Van Assche & Vouorikari (2006, p. 451)	*"Reuse is effective to the extent that a learning resource or any part of it can be fit into another learning resource or in another context for learning".*

Hence, based on the above definitions, we can conclude that the ability to reuse LOs includes the ability to reuse them in a different learning context and/or for a different targeted group and/or for the attainment of a different learning objective and/or for a different subject matter. Thus, one can note that the dimensions that affect the potential for LOs reuse are similar with the characteristics that define a learning activity (Beetham, 2007; Conole and Fill, 2005). According to Conole & Fill (2005) there are three (3) dimensions that constitute a learning activity:

- The context within which the activity occurs, this includes the subject matter (i.e., physics, geography, math, arts, etc.), the level of difficulty, the intended

learning outcomes (i.e., recall, understand, etc.) and the environment within which the activity takes place (i.e., computer-based, lab-based, etc.).

- The pedagogical approach adopted (i.e., problem based learning, inquiry based learning, etc.).
- The tasks undertaken to achieve the intended learning outcomes. Tasks can be described by the type of task (i.e., reading, writing, viewing, etc.), the techniques used (i.e., presenting, discussing, arguing, etc.), associated tools and resources (i.e., computer, software, mobile devices, etc.), the interaction (i.e., class based, group based, etc.) and roles (teacher, learner, group leader, etc.) of those involved and the assessments (i.e., formative, summative) associated with the learning activity (Falconer et al, 2006).

Based on the above discussion and assuming that the pedagogical approach adopted can be considered as part of the context within which the activity occurs (Conole, 2007; Bailey et al., 2006; Weitl et al., 2004), we adopt the following definition for the concept of LO reuse: "Learning object reuse can be defined as the extent to which a Learning Object can be used in different digital or non digital learning activities, where a learning activity is defined as the interaction of learner(s) with other(s) and with a learning environment, which emerges as a result of performing a task within a particular learning context in order to achieve one or more learning objectives".

3.2.2 Learning Objects Lifecycle

In order to study the process of LOs reuse, we need study the LOs lifecycle. In the literature there are some works that attempt to define the steps involved in the LOs lifecycle (Rensing et al., 2005; Collis & Strijker, 2004; Van Assche & Vuorikari, 2006). Most works study the LOs lifecycle in relation to the design and development of Learning Object Repositories (LOR). McGreal (2004) has defined LORs as systems that "enable users to locate, evaluate and manage learning objects through the use of "metadata", namely descriptors or tags that systematically describe many aspects of a given learning object, from its technical to its pedagogical characteristics" (p. 3). First, Collis & Strijker (2004) argue that a LO can pass through six (6) different steps (following one another) during its lifecycle:

- **Obtaining**: the first step of the lifecycle is obtaining or creating a LO.
- **Labeling**: the LO created in the previous step is described with educational metadata.
- **Offering**: the LO is offered in a LOR so that other people can find it and retrieve it.
- **Selecting**: a user searches and selects from a LOR the LO that will suit the new needs.
- **Using**: after a LO is selected, it can be used either as it is in a new environment or modified in order to match the needs of the new environment within which the LO will be used.
- **Retaining**: after the use of the LO there are three possible choices, namely, the future use of the LO, its revision or its retraction from the LOR.

There are two main weaknesses in this proposal. First, in order for individual users to make use of existing LOs, they must be able to efficiently search for LOs and then evaluate the LOs returned as a result of that search, as to whether or not they are appropriate to be reused for meeting their specific expectations (Campbell, 2003). For that reason, in our work we propose that the step of "Selecting" should be explicitly identified as separate steps, namely, searching for appropriate LOs and selection of the most appropriate ones. Second, this proposal does not take into consideration the possibility of disaggregating a LO into its constituent parts and the selection of those suitable parts for the new learning activity (Colossus, 2005; Weitl et al., 2004). Therefore, if a LO is not reused in a learning activity as it is, then, two (2) more steps may be required, that is the modification and/or the aggregation with other LOs.

Another attempt to define the steps implemented in the LOs lifecycle was made by Rensing et al (2005) where the step of "Using" in (Collis & Strijker, 2004) is further analyzed. Considering both reuse (defined by Rensing et al (2005) as, any kind of use of existing LO, which are already used in a certain learning or teaching context) and re-purposing (defined by Rensing et al., 2005) as, the modification of the LO in a way that suits a new learning or teaching context, which differs from the learning or

teaching context that the LO was created for) this proposal identifies the extra steps of:

- **Modularization** of the LO, that is splitting the LO into several smaller LOs and selecting the appropriate ones.
- **Adaptation** of the LO, namely the modification of the LO with regard to at least one of its aspects (defined by Rensing et al (2005) as language, layout or terminology) to make it fit to a new learning or teaching context.
- **Aggregation** of the LO with other LOs to create a new one.

However, this proposal does not take into consideration issues that have important influence in time and cost of development, such as the selection of the appropriate LOs, the description of the LOs derived from the reuse process with metadata and the integration of the LO into the new learning or teaching context (Van Assche & Vuorikari, 2006).

The most complete effort for the explicit definition of the steps involved in the LOs lifecycle was made by Van Assche & Vuorikari (2006). The authors describe the LOs reuse in relation to a LO quality management policy and compared to the other two proposals, they add the following steps in the process of LOs lifecycle:

- **Approve**, where a LO before published in a LOR is reviewed (i.e., peer review) in order to ensure its high quality.
- **Evaluate** that includes the criteria based on which the selection of suitable LOs for reuse is made.
- **Integrate** that includes the technical (i.e., integration in a LMS) and/or pedagogical integration (expressed as the reshuffling the sequence of LOs in their proposal) of the LO into a new learning or teaching context.

Also, Van Assche & Vuorikari (2006) present the step of “Repurpose & Reuse” where the transformation of the LO takes place so that it can be reused in a new learning or teaching context. They argue that in this step the following actions may occur:

- **Disaggregation** of the LO into its constituent parts.
- **Aggregation** of the LO with other LOs.

- **Modification** of the LO content and/or of the sequence of the constituent parts of the LO.

Yet, in literature we can find more modification types that can be applied to a LO. These are divided into three (3) main dimensions (Zimmermann et al., 2006; Colossus, 2005; Duval & Hodgins, 2003):

- **Modifications** to the LO layout/appearance, when different LOs are combined to create a new LO, then modifications to LO appearance are needed or when different accessibility needs are addressed (i.e., people with disabilities) then modifications to the display of the content is needed (i.e., white font and black background, so as to be accessible from low vision people).
- **Modifications** to the LO content, when different languages or terminology are addressed or when the sequence of the constituent parts of the LO is modified.
- **Modifications** to the LO technical format when different content delivery media and/or technology is addressed (i.e., mobile devices).

Furthermore, none of the above approaches include in the LOs lifecycle the identification of needs that will lead to the selection of an appropriate LO or, if an appropriate LO does not exist, to the development of a new one. Identification of needs and intended learning outcomes are the first factors that influence the LO development process (Palmer & Richardson, 2004). Finally, another important step not mentioned in the above approaches that encourages the LOs reuse in different learning or teaching contexts, is the step of LOs feedback. Feedback is defined as the process in which teachers and/or learners provide their advices/comments and/or ratings to a specific LO related to its use and quality (Weitl et al., 2004; Currier et al., 2004). Feedback is needed to support LO selection and maintain quality control. The feedback step could be integrated into the step of a LO's metadata characterization. However, it may include components such as rating that cannot be integrated in any of the IEEE LOM (IEEE LTSC, 2005) elements, so it is suggested to comprise an individual step.

3.3 Proposed Workflow for Learning Objects Lifecycle

Based on the discussion of existing proposals presented in the section 3.2.2, we propose a thorough workflow (including roles and their related functions) for LOs lifecycle in which LOs reuse is examined from the perspective of learning activities design and development. The proposed workflow assumes that the learning activities of an educational scenario have been already designed; we then begin with the phase of population learning activities with LOs. The participating roles in the workflow are the following:

- **Teachers**: Their role is twofold. On the one hand, they can develop new LOs to supports their learning activities, possibly describe them with educational metadata and offer them to a LOR for future use by other users. On the other hand, they can reuse existing LOs (by applying modifications or not) to support learning activities towards the attainment of specific learning objectives.
- **Authors**: One can identify two (2) categories of authors, namely, the authors of educational content (role: author-content) and the authors of educational metadata (role: author-metadata). The authors of educational content (role: author-content) are responsible for the development of educational content in the form of LOs, ensuring that the produced LOs correspond to the learning objectives that were defined by the instructional designer. Authors may consist of sub-entities such as: (a) subject experts, who are responsible for developing learning content on a specific subject (i.e., astronomy, mathematics, biology), (b) graphic designers, who are responsible for developing the graphical elements of a LO, as well as, its look and feel and (c) technical developers, who make use of specific software tools in order to implement the desirable level of interaction among the LO and its user. The authors of educational metadata (role: author-metadata) are responsible for characterizing LOs with educational metadata.
- **Instructional Designers**: They define learning objectives and they design appropriate learning activities that will lead to the accomplishment of these objectives. They are responsible for designing and/or selecting appropriate

LOs that will support the learning activities they wish to implement. Moreover, they facilitate authors to create and/or adapt LOs by providing advices regarding the instructional design of the LO, they can support the authors of metadata to describe LOs with educational metadata and they offer them to the LOR.

- **LOR Managers**: They are responsible for the LOR's policy, such as rights, terms of use and quality mechanisms. They approve and publish LOs to the LOR offered by the teachers and/or instructional designers. Finally, they are responsible for the possible retraction of LOs from the LOR.
- **Learners**: They are the final users of the LOs and the main participants in the learning activities. They also provide their feedback related to the use and quality of the LOs.

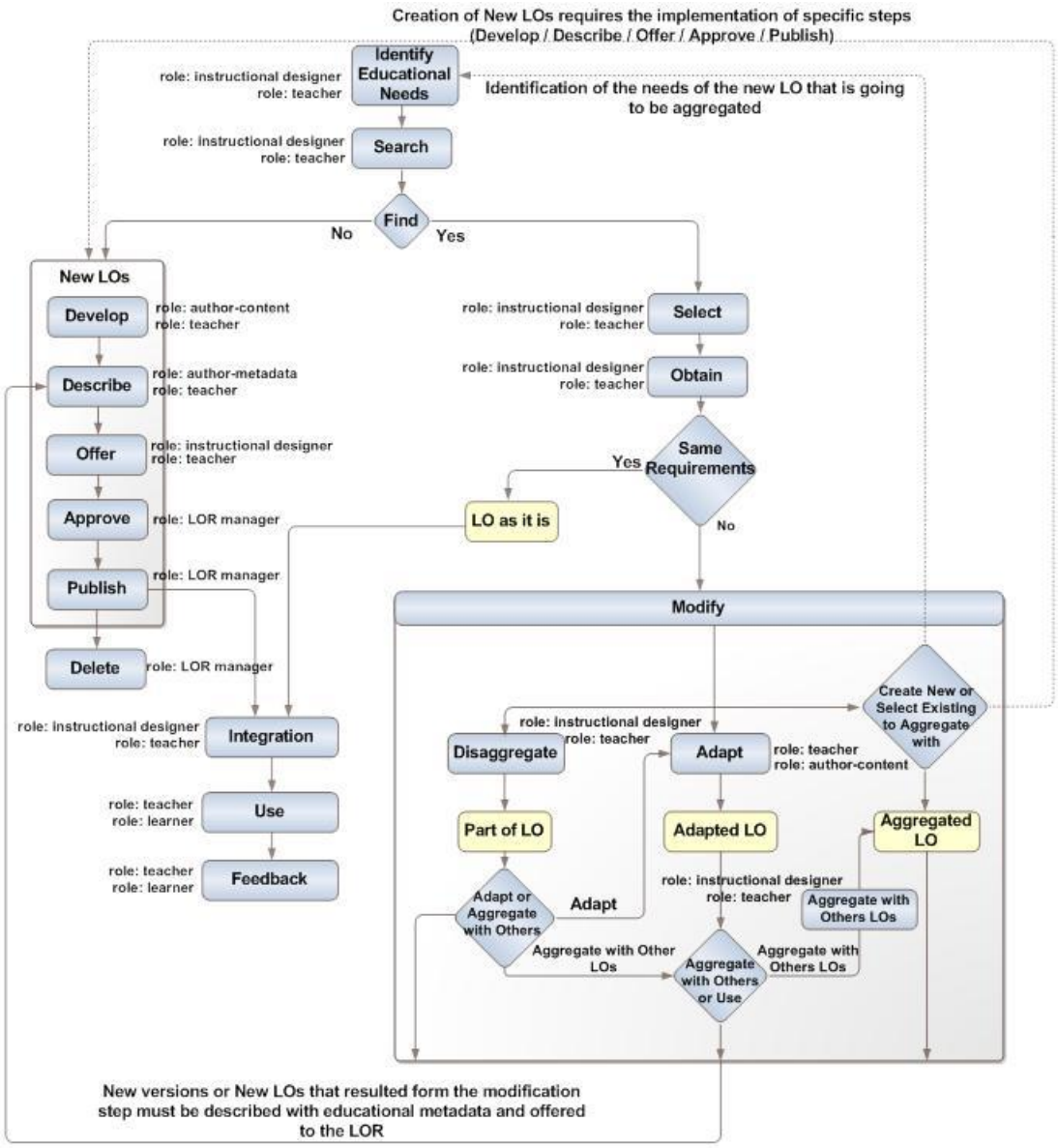


Figure 3.1: Learning Objects Lifecycle Workflow

The functions that the proposed workflow includes are described below:

- **Identify Educational Needs**: The first function of the proposed workflow is the identification of educational needs. During this function the "role:instructional designers" or the "role:teachers" define the requirements that a LO must fulfill in order to be successfully used to support the learning activity they wish to implement. Therefore, the result of this function must be the explicit definition of the dimensions of the learning activity (as they have been defined in section 3.2) in which the LO will be used.

- **Search**: Before a LO is developed from scratch the "role:instructional designers" or the "role:teachers" searches the LOR (this can be one LOR or a federation of LORs) to examine if there is one or more existing LOs that fully or partly fulfill the requirements of the new learning activity (as defined in the previous function) and, therefore, they can be reused to a certain extent. Searching in a LOR includes searching based on criteria (fill in text fields or select a value from a vocabulary) that correspond to certain metadata elements and the return of one or more results which fulfill the search criteria. The result of this function is not a LO, but one or more metadata records that correspond to the search criteria. If the search results do not return a LO that fulfill these requirements, then the "role:instructional designers" can inform the "role:authors-content" to proceed to the function of "Develop" a new LO. Alternatively, the "role:teachers" can proceed to the function of "Develop" a new LO. Otherwise, the "role:instructional designers" or the "role:teachers" proceed to the function of "Select".
- **Develop**: At this function the "role:authors-content" or the "role:teachers" develop a new LO to support the learning activity with the requirements defined by the roles that participate to the function "Identify Educational Needs".
- **Describe**: At this function the LO developed in the previous function is described with educational metadata following either IEEE LOM or an application profile created to serve specific needs. The "role:authors-metadata" characterize with educational metadata the LO developed by the "role:authors-content" or the "role:teachers" characterize with educational metadata the LO that they have developed during the previous function.
- **Offer**: The LO that has been already described with metadata in the previous function is offered to the LOR by the "role:instructional designers" or the "role:teachers", so that other users can use it.
- **Approve**: Before a LO is published to the LOR and made available to its users, it may be reviewed (according to the LOR policy) by the "role:LOR managers"(i.e., peer review) in order to ensure its quality.

- **Publish**: Since a LO has been described with educational metadata and considered to be suitable for use, it can be made available (with or without usage restrictions or cost) by the "role:LOR managers" to other users of the LOR.
- **Select**: The "role:instructional designers" or the "role:teachers" in this function should evaluate the LOs returned as a result of the function "Search" in order to select the one that satisfies to a certain extent the requirements of their learning activity. The fundamental criterion that should affect the decision of LO selection must be the requirements defined in the function "Identify Educational Needs". If a LO fulfills those requirements, then it can be reused as it is. Otherwise the LO must be modified in order to meet the specific requirements of the learning activity in hand. Other criteria that influence the decision of LO selection are comments made by other roles (role:learners and/or role:teachers), evaluations (i.e., peer review) of the LO or number of users downloaded the LO. A LO selection may be also based on copyright restrictions or cost.
- **Obtain**: Since the appropriate LO has been selected, the "role:instructional designers" or the "role:teachers" can obtain it. This sometimes requires usage permission by the owner of the LO or payment. Provided that LO fulfills the requirements of the new learning activity at the function of "Select", then the "role:instructional designers" or the "role:teachers" can reuse the LO directly after integrating it into their learning activity. Otherwise they must go the function of "Modify".
- **Modify**: Often, direct reuse of a LO is not feasible because it does not match the requirements of the learning activity that it will be used, as a result the following sub-functions may occur:
    - *Disaggregate*: In this sub-function, the "role:instructional designers" or the "role:teachers" decompose the LO into its constituent parts and those parts that match the requirements of the new learning activity are identified. The disaggregated LO constitutes a new LO. However, this LO may not be suitable as it is to cover completely the requirements of the new learning activity. Therefore the

"role:instructional designers" should inform the "role:authors-content" to proceed to the function of "Adapt" an existing LO. Alternatively, the "role:teachers" can proceed to the function of "Adapt" an existing LO.

- *Adapt*: In this sub- function, the "role:authors-content" or the "role:teachers" modify the LO, so as to fit to the requirements of the new learning activity. Adaptations may occur in the three (3) different dimensions that were defined in the previous section, namely, adaptations to the LO layout/appearance, adaptations to the LO content and adaptations to the LO technical format.
- *Aggregate with other LOs*: In this sub-function, the "role:instructional designers" or the "role:teachers" aggregate the LO with other(s) LO(s) and thus a new LO is created. The LOs used for aggregation may result from the selection through the LOR or may be new LOs developed from scratch. When existing LOs are used, then their disaggregation or adaptation may be required.

- **Integrate**: At this function the "role:instructional designers" or the "role:teachers" integrate the LO into the environment that supports the learning activity in hand.
- **Use**: At this function the LO is used in a specific learning activity by the "role:learners" and/or the "role:teachers" towards the attainment of specific learning objectives.
- **Feedback**: In order for the LOs to be retrieved and used effectively in different learning activities more information are required about how they were used in practice, beyond the information derived by their educational metadata records provided by the "role:authors-metadata" or the "role:teacher". A number of techniques are used in order for "role:learners" and/or "role:teachers" to provide feedback in the LOs of a LOR. The most commonly used techniques are comments (referring to the context of use of the LO and its usefulness) and ratings (the use of star ratings and/or hit counters that illustrate the number of downloads of a certain LO give a good

indication of users' impression about the LO) (Gehringer et al., 2007; Kay & Knaack, 2007).

- **Delete**: The "role:LOR managers", who are responsible for publishing a LO may decide that the LO must be retracted and, therefore, removed from the LOR, under certain circumstances.

3.4 Proposed Metrics for Cost Effectiveness of Learning Objects Reuse

In this paragraph, we use the proposed workflow of LOs lifecycle, so as to define metrics for cost effective LOs reuse, which can facilitate interested parties (people, organizations and initiatives) to assess the cost for systematic LOs reuse. Despite the importance of the concept of LOs reuse and its potential benefits, it seems that there are not proposed metrics for measuring the cost of LOs reuse, so as to enable us to perform a cost-benefit analysis. For this purpose, we propose to identify and adapt relevant cost metrics as in the field of software engineering.

3.4.1 Related Work: Metrics for LOs Reuse

In the field of software engineering, reuse is considered as a very important factor for productivity and quality of software systems. As a result, a number of methods have been developed to measure the cost effectiveness of software code reuse (Frakes & Terry, 1996). Component-based Software Development (CBSD) is commonly accepted as a cost effective approach, as it emphasizes on the creation of software systems using reusable components (Washizaki et al., 2003). However, although software components reuse promises reduction in the development cost and time, as well as benefits in productivity and quality, its application in practice does not necessary ensure that these benefits can be achieved. Therefore, appropriate metrics and models have been proposed as tools to measure and assess the impact of reuse (Hafefh et al., 2002).

Within this context, Poulin et al. (1993) described a set of cost metrics for software components reuse used by the IBM company (http://www.ibm.com) that are the most commonly used mainly because they are simple to understand and easy to calculate during the software development process (Mascena et al., 2005). These main cost metrics are:

- **Relative Cost of Reuse (RCR)**, which is defined as the cost for reusing a software component divided by the cost normally incurred to develop it for one-time use.
- **Relative Cost of Writing Reusable Software (RCWR)**, which is defined as the cost for developing a reusable software component divided by the cost of developing it for one-time use.

These metrics can be used as input in a return on investment model (ROI), upon which managers may rely their business decisions.

In the TeL literature, there are some works that have applied metrics from the software engineering field for the purpose of measuring the potential reusability of learning objects. Cuadrado & Sicilia (2005) explores the possibility of using existing object oriented design metrics proposed by Chidamber & Kemerer (1994) and adapting them to the LO domain, so as to measure the complexity of individual LOs internal structure and consequently assess their potential reusability. Cervera et al (2009) have also adapted these metrics in their study to measure potential reusability and quality of individual LOs by means of correlation between these metrics and their metadata. Finally, Mat Noor et al (2009) applied the metrics proposed by Cuadrado & Sicilia (2005), so as to measure the potential reusability of individual LOs selected from existing LORs (such as MERLOT and SMETE). However, these works assess only the potential reusability of individual LOs and they do not propose metrics for measuring whether the process of LOs reuse is cost effective in practice. In order to achieve that, we should be able to perform a cost-benefit analysis within a well-defined workflow of the LOs lifecycle (this has been defined in previous section), where cost variables can be assigned for each function of the workflow and metrics for cost effective LOs reuse can be defined.

3.4.2 Proposed Metrics

In this paragraph, we assign cost variables that correspond to all different functions of the proposed workflow of LOs lifecycle, so as a cost-benefit analysis to be feasible. Table 3-2 presents these variables.

Table 3-2: Identified Costs of the Proposed LOs Lifecycle Workflow

LOs Lifecycle Workflow Functions	Cost Variable
Identification of Educational Needs	C_{needs}
Search	C_{search}
Selection	C_{select}
Obtain	C_{obtain}
Disaggregation	$C_{disaggregate}$
Adaptation	C_{adapt}
Aggregation with Other	$C_{aggregate}$
Integration	$C_{integrate}$
Feedback	$C_{feedback}$
Description	$C_{metadata}$
Offer	C_{offer}
Approval	$C_{approve}$
Publish	$C_{publish}$
Development	$C_{develop}$

Next, we present a set of metrics that can facilitate measuring the cost effectiveness of LOs reuse.

3.4.2.1 Cost to Create a Single Non-Reusable LO (C2CNRLO)

This metric is defined as the cost needed to develop a non-reusable LO from scratch. According to the proposed LOs lifecycle workflow, the functions that are needed to develop a single non-reusable LO are: a) identify educational needs, b) develop, c) integrate and d) feedback. As a result, C2CNRLO metric can be calculated using the following formula:

$$C2CNRLO = C_{needs} + C_{develop} + C_{integrate} + C_{feedback}$$

3.4.2.2 Additional Cost for Reusable LO (ADC4RLO)

This metric is defined as the additional cost needed to create a reusable LO. According to the proposed LOs lifecycle workflow, the additional functions that are needed to develop a reusable LO are: a) describe, b) offer, c) approve and d) publish. As a result, ADC4RLO metric can be calculated using the following formula:

$$ADC4RLO = C_{metadata} + C_{offer} + C_{apporve} + C_{publish}$$

We should mention here that ADC4RLO takes its maximum value if the particular LO is reused only once. Provided that the particular LO is frequently reused, then ADC4RLO could be reduced to practically zero.

3.4.2.3 Cost to Create a Single Reusable LO (C2CRLO)

This metric is defined as the cost needed to create a reusable LO from scratch. According to the proposed LOs lifecycle workflow, the cost needed to create a reusable LO (C2CRLO), includes the cost needed to create a non-reusable LO (C2CNRLO), as well as the additional cost needed to create a reusable LO (ADC4RLO). As a result, C2CRLO metric can be calculated using the following formula:

$$C2CRLO = C2CNRLO + ADC4RLO$$

3.4.2.4 Cost to Create a Sequence of LOs within a new Learning Activity (C2CLO)

This metric is defined as the cost needed to create from scratch non-reusable LOs (C2CNRLO) and/or reusable LOs (C2CRLO) for the needs of a new learning activity. This metric can be calculated as follows:

$$C2CLO = \sum_{i=1}^{K1} C2CNRLO_i + \sum_{i-1}^{K2} C2CRLO_i$$

Where:

- (K_1) is the number of non-reusable LOs developed for the purpose of the new learning activity.
- (K_2) is the number of reusable LOs developed for the purpose of the new learning activity.

3.4.2.5 Cost to Reuse a Single LO within a new Learning Activity (C2RLO)

This metric is defined as the cost needed to reuse a LO (with or without modifications). According to the proposed LOs lifecycle workflow, we should examine two (2) cases:

- *Cost to reuse a LO without modifications in the new learning activity ($C2RLO_{AsIs}$)*: when a LO is reused without modifications in a new learning activity, then the functions that are implemented based on the proposed LOs lifecycle workflow are the following: a) identify educational needs, b) search, c) select, d) obtain, e) integrate and f) feedback. As a result, C2RLOAsIs metric can be calculated using the following formula:

$$C2RLO_{AsIs} = C_{needs} + C_{search} + C_{select} + C_{obtain} + C_{integrate} + C_{feedback} = (C2CRLO - C_{develop}) + C_{search} + C_{select} + C_{obtain}$$

- Cost to reuse a LO after modifications in the new learning activity ($C2RLO_{modify}$): when a LO is reused after modifications in a new learning activity, then the functions that are implemented based on the proposed LOs lifecycle workflow are the following: a) identify educational needs, b) search, c) select, d) obtain e) disaggregate f) adapt, g) aggregate with others, h) describe, i) offer, j) approve, k) publish, l) integrate and m) feedback,. In this case except the additional functions (in relation to the case of reusing a LO without modifications) that may emerge due to LO modification (namely, disaggregate, adapt, aggregate with other LOs), the functions of description, offer, approval and publish to the LOR have been added, since it is most likely that a modified LO needs to have its educational metadata updated and it must be offered to the LOR as a new LO in order to be available to other users. Consequently, within the context of calculating the Cost to Reuse a LO after modifications, we should examine three complementary (3) cases:
    - Cost to reuse after disaggregation ($C2RLO_{disaggregate}$): this metric can be calculated using the following formula:

$C2RLO_{disaggregate} = C_{needs} + C_{search} + C_{select} + C_{obtain} + C_{disaggregate} + C_{metadata} + C_{offer} + C_{apporve} + C_{publish} + C_{integrate} + C_{feedback} = (C2CRLO - C_{develop}) + C_{search} + C_{select} + C_{obtain} + C_{disaggregate}$

- Cost to reuse after adaptation ($C2RLO_{adapt}$): this metric can be calculated using the following formula:

  $C2RLO_{adapt} = C_{needs} + C_{search} + C_{select} + C_{obtain} + C_{adapt} + C_{metadata} + C_{offer} + C_{apporve} + C_{publish} + C_{integrate} + C_{feedback} = (C2CRLO - C_{develop}) + C_{search} + C_{select} + C_{obtain} + C_{adapt}$

- Cost to reuse after aggregation with other LOs ($C2RLO_{aggregate}$): this metric can be calculated using the following formula:

  $C2RLO_{aggregate} = C_{needs} + C_{search} + C_{select} + C_{obtain} + C_{aggregate} + C_{metadata} + C_{offer} + C_{apporve} + C_{publish} + C_{integrate} + C_{feedback} = (C2CRLO - C_{develop}) + C_{search} + C_{select} + C_{obtain} + C_{aggregate}$

As a result, the cost to reuse a a single LO within a new learning activity could be equal to the following minimum and maximum values:

$$C2RLO = \begin{cases} (min)\ (C2CRLO - C_{develop}) + C_{search} + C_{select} + C_{obtain} = C2RLO_{AsIs} \\ (max)\ (C2CRLO - C_{develop}) + C_{search} + C_{select} + C_{obtain} + (C_{aggregate} + C_{disaggregate} + C_{adapt}) = C2RLO_{modify} \end{cases}$$

The total cost of reusing LOs in a new learning activity can be calculated as follows:

$$C2RLO = \sum_{i=1}^{M1} C2RLO_{AsIs\ LOi} + \sum_{i=1}^{M2} C2RLO_{modify\ LOi}$$

Where:

- (M_1) is the number of LOs reused without modifications for the purpose of the new learning activity.
- (M2) is the number of LOs reused after modifications for the purpose of the new learning activity.

3.4.2.6 Cost Benefit due to Reuse LO (CB2RLO)

This metric is defined as the total cost benefit that derives from the total cost of creating a sequence of non-reusable LOs and/or reusable LOs minus the cost of reusing LOs (with or without modifications) for the same learning activity. As a result, CB2RLO metric can be calculated using the following formula:

$$CB2RLO = C2CLO - C2RLO$$

3.5 Results and Discussion

Based on the proposed metrics for measuring the cost effectiveness of LOs reuse, we can discuss the conditions of different cases, in which LOs reuse can be considered as cost effective. For this purpose, we examine the Cost Benefit due to Reuse (CB2RLO) metric, which should have a positive value, so as to consider that the LOs reuse is cost effective. This means that the following formula should be valid:

$$CB2RLO = C2CLO - C2RLO > 0 \Rightarrow C2CLO > C2RLO \Rightarrow$$

$$\sum_{i=1}^{K1} C2CNRLO_i + \sum_{i-1}^{K2} C2CRLO_i > \sum_{i=1}^{M1} C2RLO_{AsIsLOi} + \sum_{i=1}^{M2} C2RLO_{modifyLOi} \quad (1)$$

Assuming that: $K_1+K_2 = M_1+M_2$

From the above formula, we can consider the following four (4) cases:

1. *The learning activity can be designed with non-reusable LOs that are developed from scratch or by reusing LOs without any modification:* for this case, formula (1) is transformed as follows:

   $\sum_{i=1}^{K} C2CNRLO_i > \sum_{i=1}^{K} C2RLO_{AsIsLOi}$. By analyzing this formula, we get the following result:

   $$\sum_{i=1}^{K} C_{develop} > \sum_{i=1}^{K} (C_{search} + C_{select} + C_{obtain}).$$

2. *The learning activity can be designed with non-reusable LOs that are developed from scratch or by reusing LOs which have been all modified:* for this case, formula (1) is transformed as follows:

$\sum_{i=1}^{K} C2CNRLO_i > \sum_{i=1}^{K} C2RLO_{modifyLOi}$. By analyzing this formula, we get the following result:

$$\sum_{i=1}^{K} C_{develop} > \sum_{i=1}^{K} (C_{search} + C_{select} + C_{obtain} + C_{disagregate} + C_{aggregate} + C_{adapt} + ADC4RLO).$$

3. *The learning activity can be designed with reusable LOs that are developed from scratch or by reusing LOs without any modification:* for this case, formula (1) is transformed as follows:

   $\sum_{i=1}^{K} C2CRLO_i > \sum_{i=1}^{K} C2RLO_{AsIsLOi}$. By analyzing this formula, we get the following result:

   $$\sum_{i=1}^{K} (C_{develop} + ADC4RLO) > \sum_{i=1}^{K} (C_{search} + C_{select} + C_{obtain}).$$

4. *The learning activity can be designed with reusable LOs that are developed from scratch or by reusing LOs which have been all modified:* for this case, formula (1) is transformed as follows:

   $\sum_{i=1}^{K} C2CRLO_i > \sum_{i=1}^{K} C2RLO_{modifyLOi}$. By analyzing this formula, we get the following result:

   $$\sum_{i=1}^{K} C_{develop} > \sum_{i=1}^{K} (C_{search} + C_{select} + C_{obtain} + C_{disagregate} + C_{aggregate} + C_{adapt}).$$

If we group the costs, C_{search} + C_{select} + C_{obtain} and consider them as a total cost for searching and obtaining LOs from a typical LOR and if we also group the costs $C_{disaggregate}$ + $C_{aggregate}$ + C_{adapt} and consider them as a total cost for modifying an existing LO then from the formulas described above, we can conclude the following:

- **Case 1:** The process of reusing a sequence of LOs (without any modifications) for a new learning activity is cost effective only if the sum of the costs to search and obtain them from a LOR is lower than the sum of the costs to develop them (as non-reusable LOs) from the scratch.

- **Case 2:** The process of reusing a sequence of LOs (with modifications) for a new learning activity is cost effective only if the sum of the costs of: a) searching and obtaining them from a LOR, b) modifying them and c) offering them back to the LOR is lower than the sum of the costs to develop them (as non-reusable LOs) from the scratch.
- **Case 3:** The process of reusing a sequence of LOs (without any modifications) for a new learning activity is cost effective only if the sum of the costs to search and obtain them from a LOR is lower than the sum of the costs to develop them from the scratch as reusable LOs and offer them to the LOR.
- **Case 4:** The process of reusing a sequence of LOs (with modifications) for a new learning activity is cost effective only if the sum of the costs of: a) searching and obtaining them from a LOR and b) modifying them is lower than the sum of the costs to develop them from the scratch as reusable LOs and offer them to the LOR.

For cases 2 and 3, we should mention that Additional Cost for Reusable LO (ADC4RLO) could be reduced to practically zero provided that the particular LO is frequently reused.

An essential cost of the LOs reuse process is the cost of searching and obtaining LOs from LORs. For this purpose, it is important that the LOs process of reuse is supported by effective LORs that can significantly facilitate their end users to narrow their search results and select more easily LOs for reuse within a given learning activity. This will substantially lower the costs for searching and obtaining LOs from the LORs and will make the LOs reusability process more cost effective. Moreover, when modifications to the LOs are needed these increase significantly the cost compared to the cost needed to create the LO from scratch and reduce the potential cost benefits of reuse. Therefore, further analysis would be needed to study under which circumstances LO modifications are costs effective over LO development from scratch. This observation supports the need for LORs to stimulate the versioning and its sharing among LOR users. Finally, possible automatic modifications (i.e., automatic LO modification for different disability categories) can significantly lower the cost of LOs reuse.

3.6 Conclusions

In this chapter, we have studied the concept of LOs reuse within the context of LAs design and development, we studied and discussed the limitations of existing proposals for LOs reuse and we proposed a thorough workflow for LOs lifecycle that can capture LOs reuse processes.

Based on this workflow, we proposed a set of metrics for measuring the cost of LOs reuse as a process rather than measuring only the potential reusability of individual LOs. This is an important issue for large scale deployment of the LO paradigm, since it contributes towards assessing the conditions for LOs reuse being cost effective. The proposed metrics bare the potential for cost benefit analysis of the LOs reuse process from interested parties within the framework of OERs initiatives.

In the next chapter, we define an appropriate case study for applying and evaluating the hierarchical framework (defined in section 2.3) towards supporting LOs reuse.

4 Applying the Proposed Hierarchical Framework for Supporting Open Access and Reuse to Accessible Technology enhanced Training[7]

4.1 Introduction

Over the past years, accessibility has been recognized as a key design consideration for technology-enhanced training systems ensuring e-inclusion of people with disabilities in the training process and consequently, preventing risks of "digital exclusion" (Earl et al., 2008; Di Iorio et al., 2006). As a result, a number of systems have been proposed such as: e-Learn-Vip (http://www.e-learn-vip.org/), SYNENNOESE (Karpouzis et al., 2007) and DEAL (http://www.deal-leonardo.eu/) aiming to meet the training needs of people with disabilities. However, most of these systems: (a) are typically supported only by digital training resources that are specially designed to meet the accessibility requirements of a particular user group and (b) their training activities are not represented in such a way that they can be identified and inter-exchange between the various systems (Mirabella et al., 2004).

Main drawbacks of these approaches are that (a) the development of special-purpose digital training resources is costly and thus, their limited sharing and reuse increases the barriers of certain categories of learners with disabilities in accessing technology-facilitated training services, and (b) valuable experiences from best technology-facilitated training practices, gained through local use, can not be easily identified and adopted by larger communities of educational practitioners and training organizations. Therefore, there is a strong need for technology-supported solutions to the above mentioned problems. Within this context, in this chapter we apply the hierarchical framework (defined in section 2.3) for supporting open access and reuse to accessible Technology-enhanced Training.

The chapter is organized as follows: First, we discuss the issue of accessibility in Technology-Enhanced Training and we present the current initiatives and

[7] This chapter is an adapted copy of the following published journal paper:

D. Sampson and P. Zervas, "Supporting Accessible Technology-Enhanced Training: The eAccess2Learn Framework", IEEE Transactions on Learning Technologies (TLT), vol. 4(4), pp. 353-364, IEEE Computer Society, October 2011

approaches on enhancing accessibility in technology-enhanced training systems. Next, we describe the customization of the hierarchical framework for facilitating design and production of accessible eTraining Resources and Courses that can be interoperable between different eTraining Platforms and Systems and we present the tools and services of the customized hierarchical framework. Finally, we present experiments for evaluating the customized hierarchical framework within the context of designing and developing accessible eTraining Resources and Courses for two (2) disabled user groups, namely, low vision and motor disabled people.

4.2 Technology-enhanced Training and Accessibility

The issue of accessibility in relation to Technology-enhanced Training is understood as ensuring that learners are not prevented from accessing technology-supported resources, services and experiences in general due to their disability (Sale & Cooper, 2009; ISO/IEC JTC1/SC36, 2008). There have been many generic definitions of the term accessibility, mainly focused on reducing barriers to accessing the web and ensuring equal access to all users (WAI, 2005; Paciello, 2000). According to Harper & Yesilada (2008): "*Web accessibility conjures the vision of designers, technologists and researchers valiantly making the World Wide Web (Web) open to disabled users*". The IMS Global Learning Consortium offers an education specific definition of both disability and accessibility: "*the term disability has been re-defined as a mismatch between needs of the learner and the education offered. It is therefore not a personal trait, but an artifact of the relationship between the learner and the learning environment or education delivery. Accessibility, given this re-definition, is the ability of the learning environment to adjust to the needs of all learners. Accessibility is determined by the flexibility of the education environment (with respect to presentation, control methods, access modality and learner supports) and the availability of adequate alternative-but-equivalent content and activities*" (IMS GLC, 2004). It is important to point out that this definition of disability has been adopted by the ISO/IEC Standard 24751 "Individualized Adaptability and Accessibility in e-Learning, Education and Training". ISO/IEC 24751 is intended to meet the needs of learners with disabilities and anyone in a disabling context and provides a common framework to describe and specify learner needs and preferences on the one hand

and the corresponding description of the digital learning resources on the other hand, so that individual learner preferences and needs can be matched with the appropriate user interface tools and digital learning resources (ISO/IEC JTC1/SC36, 2008).

In relation to the aforementioned definition, there are three (3) main approaches for enhancing accessibility in technology-enhanced training:

- The first and most common approach is to create Universally Accessible Resources that meet all the accessibility requirements. The main drawback of this approach is that, typically, resources may be accessible by everyone but optimal for no one (Bowe, 2000).
- The second approach used by a number of educational content providers is to create multiple versions of the resources, customized based on the different needs and expectations of the anticipated individual user. While this solves some of the problems with the first approach, it causes new problems, such as the increased costs that eventually result to poor maintenance of these resources, compared to their default version, eventually, providing learners with disabilities with out-of-date and different versions of the digital content (Nevile et al., 2005).
- The third approach is to build Universally Accessible Systems, that is, systems that can handle learner-centered configurations of resources and/or tools/applications. This is known as the AccessForAll Approach (Nevile & Treviranus, 2006). The AccessForAll Approach requires accurate descriptions of both the learners' preferences and/or needs, as well as of the available resources and/or the tools/applications characteristics. However, early systems implementation suffered by the lack of interoperability considerations (that is, sharing resources, activities and their underlying training practice between systems was not guaranteed), adding extra barriers to the AccessForAll Approach.

The emerge of the Learning Technology Specifications, such as, the IMS Accessibility for Learner Information Package (IMS GLC, 2003b), the IMS AccessForAll Metadata (IMS GLC, 2004) and the IMS Guidelines for Developing Accessible Learning

Applications (IMS GLC, 2002) and Web Accessibility Standards, such as the Web Content Accessibility Guidelines (W3C, 2008; W3C, 1999), the User Agent Accessibility Guidelines (Jacobs et al., 2002), the Authoring Tool Accessibility Guidelines (Treviranus et al, 2000), bare the potential towards improving this situation, although still global adoption is at very early stages and extra effort is needed to ensure synchronization and further adoption of these specifications in real life applications.

4.3 Accessibility Dimensions

As we already implied, the design of accessible technology-enhanced training systems is defined upon three (3) dimensions, namely, the description of learners' preferences and/or needs, as well as, the characteristics of resources and tools/applications. Furthermore, another important dimension, which is well recognized in studies of accessible systems design, is the context of use (Keates & Clarkson, 2003; Stary, 2002; Stephanidis, 2001). In this section, we further discuss these four (4) identified key dimensions in accessible technology-enhanced training systems design.

4.3.1 Learner Dimension

This dimension includes the expression of the individual learner accessibility preferences and the modeling of those preferences into reusable information records. One way to achieve this is by using the IMS Accessibility for Learner Information Package Specification (IMS AccLIP) (IMS GLC, 2003b). IMS AccLIP adds a new element on IMS Learner Information Package (IMS LIP) (IMS GLC, 2005) to allow learner <accessibility> preferences to be explicitly defined. Rather than targeting at the implicit description of the learner's disabilities, it allows users to explain explicitly how they interface and use a technology-enhanced training system, with their preferences being grouped into <display>, <control>, and <content> elements (IMS GLC, 2003b). This offers a flexible user-controlled process for the definition of the learners' characteristics in relation to the pre-conditions under which the learner interacts with the system, although it does not handle the conditions and features of the current learning situation, needed to be handled by the context dimension.

4.3.2 Resources Dimension

This dimension includes the design of resources that are accessible from a specific target group with given disabilities and their tagging with appropriate metadata. The common way for generating accessible digital resource has been by applying the W3C Web Content Accessibility Guidelines 1.0 and their evolution W3C Web Content Accessibility Guidelines 2.0 (W3C, 1999; W3C, 2008). On the other hand, typically, educational resources are described with the IEEE Learning Object Metadata Standard (IEEE LOM) (IEEE LTSC, 2005), so as to be searched, found and retrieved through established web-based repositories. However, IEEE LOM does not directly support the description of educational resources in terms of their relevance to accessibility characteristics. Efforts have been made to develop Application Profiles of the IEEE LOM Standard that can be used for tagging educational resources with accessibility relevant information (Karampiperis & Sampson, 2004).

Another way to characterize accessible educational resources with metadata is by using the IMS AccessForAll Metadata Specification (IMS AccMD), which aims to provide with metadata that expresses the resource's ability to match the needs and preferences of a certain learner's IMS AccLIP profile. It is intended to assist with resource discovery and also to provide a way that can support the substitution and augmentation of a resource or a resource component with equivalent or supplementary components as required by the accessibility needs and preferences expressed in a learner's IMS AccLIP profile (IMS GLC, 2004). The main disadvantage of this approach is that it relates the description of resources to the description of the learner's condition characteristics in a rather hard-wired way thus, reducing the interoperability only between systems that adopt both the IMS AccLIP and the IMS AccMD specifications.

4.3.3 Tools/Applications

This dimension includes the definition of tools'/applications' accessibility features in relation to the required assistive technology that the tool/application should support. This process can be based on the use of the IMS Guidelines for Developing Accessible Learning Applications, which include the following design considerations (IMS GLC, 2002): (a) accessible delivery of text, audio, images, and multimedia, (b)

developing accessible synchronous and asynchronous communication and collaboration tool, (c) developing testing and evaluation tools, including self-assessment and multiple-choice testing, (d) developing accessible authoring tools, and (e) legal issues for accessible distance learning.

An example of a well known system that conforms to the IMS Guidelines for Developing Accessible Learning Applications is the ATutor (http://www.atutor.ca/) Open Source Course Management System developed by the Adaptive Technology Resource Centre of the University of Toronto. ATutor is an accessible Course Management System (CMS), built around IMS Access for All specifications, which aims to allow access to all potential learners, instructors, and administrators, including those with disabilities who may be accessing the system using assistive technologies.

4.3.4 Context Dimension

This dimension includes the definition of the conditions and features of the learning situation in hand. Context has been defined by Dey (2001) as "*any information that can be used to characterize the situation of an entity. An entity is a person, place or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves*".

In relation to learning, context can be described as "*the current situation of a person related to a learning activity*" (Luckin, 2010). Learning context is an important issue in technology-enhanced training today, especially, when adaptations and/or customized support is anticipated. Additionally, learning context can be used for making meaningful and accurate recommendations for learning systems configurations and consequently lead to better learning experiences (Zimmermann et al., 2005; Luckin, 2007).

4.4 Customizing and Extending the Proposed Hierarchical Framework

As already discussed, an important drawback of accessible technology-enhanced training systems has been the lack of interoperability of the educational resources and the educational practices between different systems and platforms. In this chapter, we customize the proposed hierarchical framework (defined in section 2.3)

for supporting the main stages of a typical e-Learning chain, namely, creation, publication, discovery, acquisition, access, use and reuse of accessible digital training resources and courses, while retaining their interoperability between various eTraining Systems and Platforms.

4.4.1 User Roles

The customized hierarchical framework (namely, eAccess2Learn Framework) identifies three (3) main user roles in technology-enhanced training, as follows:

- **eTraining Content Suppliers**, that is, the user role responsible for designing and developing independent eTraining Resources in the form of LOs. The eTraining Content Suppliers need to (a) be able to convert their existing eTraining Resources and/or create new digital resources that meet accessibility requirements of people with disabilities, and (b) be able to characterize these resources with metadata that are meaningful in relation to the accessibility characteristics of the resources. Thus, the hierarchical framework has been customized for providing them with a set of guidelines and the technological means for developing accessible eTraining Resources and tagging them with appropriate educational metadata.
- **eTraining Courses Suppliers**, that is, the user role responsible for designing eTraining Courses based on a predefined scenario (Course Template) that reflects the adopted training approach. For the purposes of the customized framework an eTraining Course is defined as: "*a sequence of learning activities conducted entirely through the web, targeting specific educational objects and lasting for 8 to 16 didactical hours in total*" (Alonso et al, 2005). Moreover, we adopted the following definition for the concept of eTraining Course Template: "*an eTraining Course Template can be defined as a pedagogical model for an eTraining course, focused on the sequence of generic learning activities that will support teachers and designers to develop particular kinds of learning experiences, one of the aims of an eTraining Course Template is to enable the features of a successful eTraining course to be applied to other eTraining Courses so these may also promote successful outcomes for learners*" (McAlpine & Allen, 2007). Thus, the hierarchical

framework has been customized for providing to the eTraining Course Suppliers with a methodology and the technological means for defining their eTraining strategies and for representing them in a common machine understandable format following the IMS Learning Design specification (IMS GLC, 2003a). Furthermore, the hierarchical framework has been customized for providing them with a set of best practice examples of Generic eTraining Course Templates which they can use and modify according to their eTraining strategies, and offers them access to a web-based repository of eTraining Resources (in the form of Learning Objects characterized with appropriate educational metadata), which can both facilitate them in the design and the development of their eTraining Courses.

- **eTraining Services Providers**, that is, the user role responsible for designing eTraining Programmes as a synthesis of eTraining Courses and delivering them to people with disabilities. The hierarchical framework has been customized for providing them with access to a repository of eTraining Courses (represented in the form of IMS Learning Designs) which they can use to search and retrieve eTraining Courses, so as to integrate them to their course management systems.

Figure 4.1 presents the identified user roles, their interconnections, as well as, their needs and the tools/services that the customized hierarchical framework offers them to support these needs.

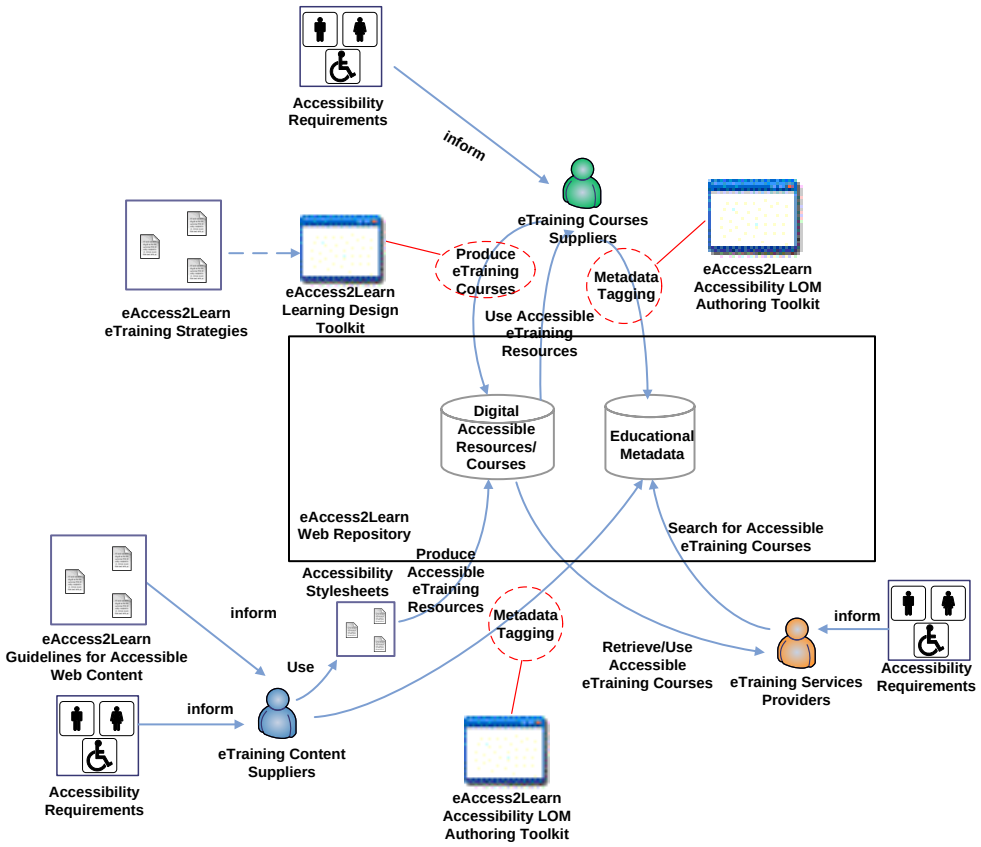


Figure 4.1: The Customized Hierarchical Framework (namely, eAccess2Learn Framework) for Supporting Open Access and Reuse to Accessible Technology enhanced Training

4.4.2 Tools and Services

The eAccess2Learn framework provides to the main user roles identified in section 4.4.1, a set of key services and tools that are described next in details.

4.4.2.1 eAccess2Learn Learning Design Toolkit for Designing eTraining Course Templates and eTraining Courses

This is a customized version of the ASK-LDT Tool that has been presented in section 2.3.3.4. It has been customized to support the needs of the eTraining Course Suppliers of the eAccess2Learn Framework. More specifically, eTraining Course Suppliers are able (a) to express their eTraining strategies, in the form of eTraining Course Templates, using a common machine understandable way and (b) to design and develop eTraining Courses using a Reference Set of pre-defined eTraining Course Templates. As a result, a set of eTraining Course Templates, which are following different eTraining strategies (suitable for disabled people training), can be designed

to facilitate the development of eTraining Courses that adopt these strategies. Figure 4.2 presents a snapshot of the eAccess2Learn Learning Design Toolkit, which provides eTraining Courses Suppliers with a graphical user-friendly interface for creating eTraining Courses conformant with IMS Learning Design Specification (IMS GLC, 2003a) and packaging them along with their related eTraining Resources. Furthermore, by using the eAccess2Learn Learning Design Toolkit, eTraining Courses Suppliers can exchange eTraining Strategies and/or Courses, assess their application at a local/national/global context of use, and reflect to the feedback for further improvements to either eTraining Strategies or eTraining Courses.

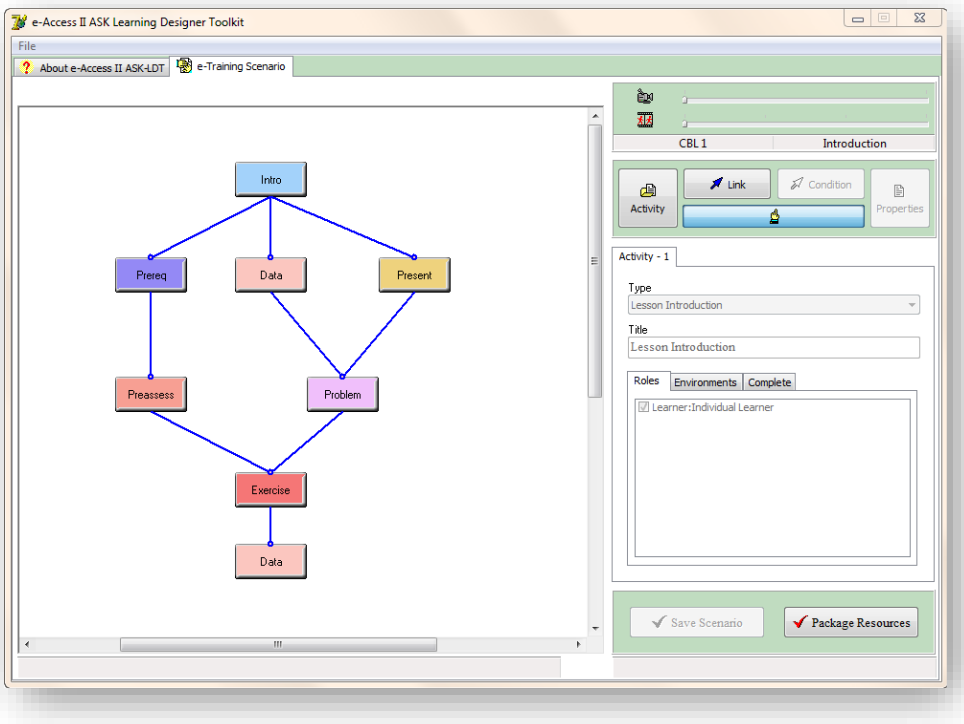


Figure 4.2: Creating a new eTraining Course based on a pre-defined Course Template

4.4.2.2 eAccess2Learn Guidelines and Style Sheets for Developing Accessible Web-Based Training Content

This is a service that includes the provision of (a) a set of mandatory guidelines, based on the W3C Web Content Accessibility Guidelines 1.0 (W3C, 1999), which can be followed by the eTraining Content Suppliers to ensure that their newly produced eTraining Resources meet accessibility requirements for visually impaired and motor

disabled people and (b) a set of Cascading Style Sheets (CSS) for HTML-based content that facilitate eTraining Content Suppliers to transform the presentation of the HTML elements (e.g. text size/colour, foreground/background color, buttons, links etc) of their existing eTraining Resources, so as to be understandable and navigable from low vision, colour blind and motor disabled people.

The eAccess2Learn guidelines aim to address three (3) general dimensions, namely, the presentation, the understandability and the navigability of the eTraining Resources. These dimensions are similar with the different themes of accessible design that the Web Content Accessibility Guidelines addresses (W3C, 1999; W3C, 2008). Figure 4.3 presents an implementation example of the eAccess2Learn Guidelines for developing accessible web-based training content. More specifically, since text is considered potentially accessible to all users as it can be handled by (a) screen readers, (b) non-visual browsers and (c) braille readers (W3C, 1999; W3C, 2008), non-textual information (images, applets, sounds, multimedia presentations) should be followed by textual equivalents. Additionally, especially for colour blind people, information conveyed with colour should be also available without it, through alternative descriptions.

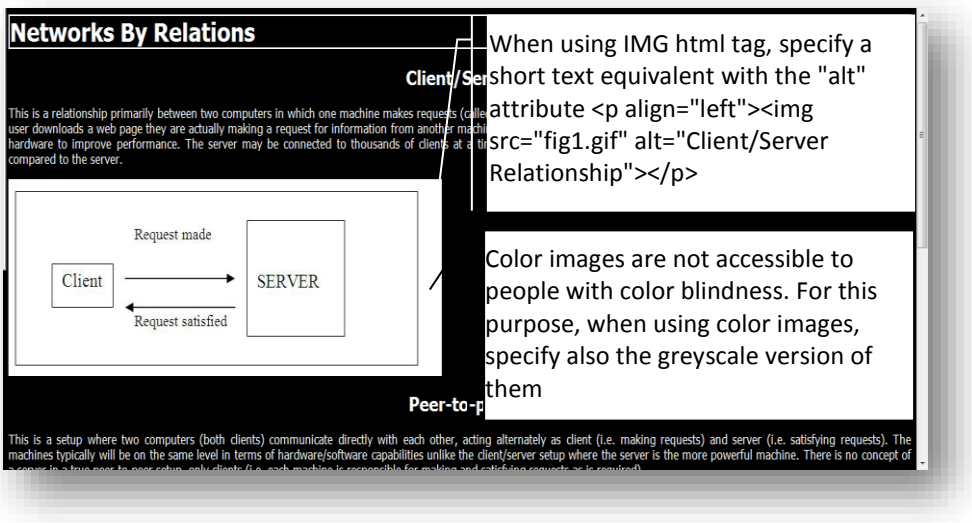


Figure 4.3: Implementation Example of the eAccess2Learn Guidelines

Moreover, the presentation of the content in HTML pages should be controlled with style sheets rather than with presentation elements and attributes applied directly to the HTML elements (W3C, 1999; W3C, 2008). For this purpose, three different

style sheets have been developed for controlling the presentation of HTML-based content for three (3) disability categories, namely, motor disabled, low vision and color blind people. Figure 4.4, Figure 4.5, Figure 4.6 and Figure 4.7 present the application of the eAccess2Learn Accessibility Style Sheets to the same HTML content. The HTML content is accordingly transformed to be understandable and navigable for visually impaired (low vision and color blind) and motor disabled people. More precisely, when the Style Sheet for color blind people is applied the HTML page is transformed, so as only black and white colors are used. In case the Style Sheet for low vision is applied, the HTML page is transformed, so that the font size to become larger and the contrast between background and foreground to become higher. Additionally, the hyperlinks and the buttons of the HTML page are transformed, so that to become larger and with higher contrast compared to the background. Finally, when the motor disabled Style Sheet is applied the hyperlinks are becoming larger, so as to enable persons with motor disabilities to click easier on the hyperlinks.

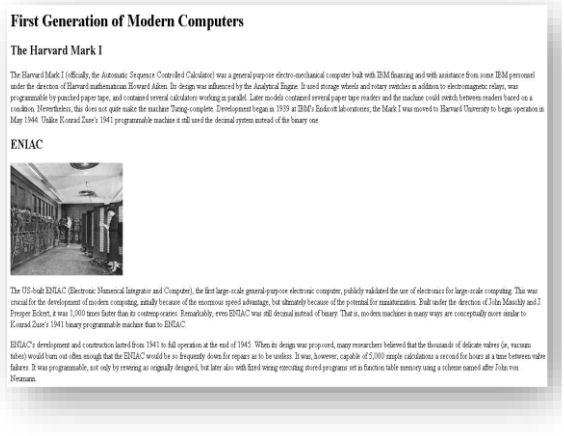


Figure 4.4: HTML Content without eAccess2Learn Style Sheets Applied

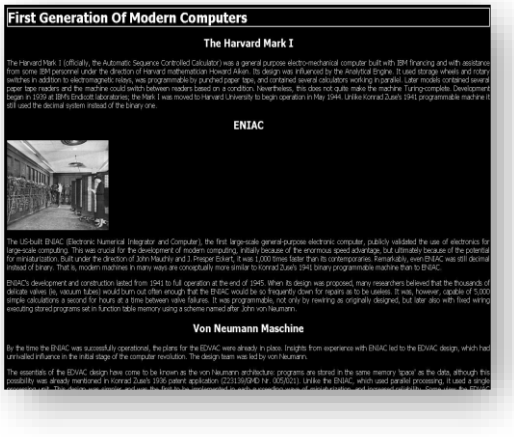


Figure 4.5: HTML Content with eAccess2Learn Style Sheet for Color Blind People Applied

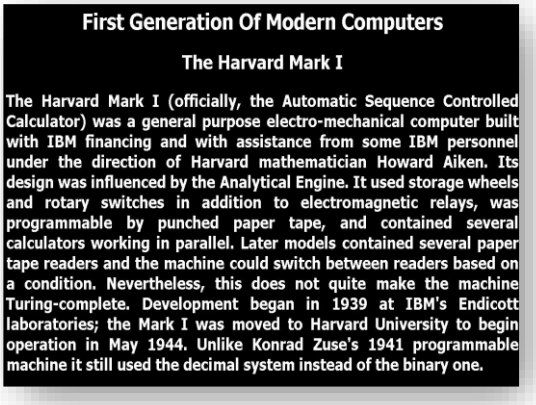


Figure 4.6: HTML Content with eAccess2Learn Style Sheet for Low Vision People Applied

Figure 4.7: HTML Content with eAccess2Learn Style Sheet for Motor Disabled People Applied

4.4.2.3 eAccess2Learn Accessible Learning Objects Metadata Authoring Toolkit

This is a customized version of the ASK-LOM-AT 2.0 Tool that has been presented in section 2.3.3.1. It has been customized to support eTraining Content Suppliers and the eTraining Courses Suppliers in authoring educational metadata for their eTraining Resources and eTraining Courses, as well as, in organizing and offering of eTraining Resources and Courses through the eAccess2Learn Web Repository. Figure 4.8 presents screenshots of the eAccess2Learn Accessible Learning Objects Metadata Authoring Toolkit. This toolkit aims to provide eTraining Content Suppliers and eTraining Courses Suppliers with a user-friendly authoring wizard for describing their

eTraining Resources and Courses with educational and accessibility metadata conformant with IEEE Learning Objects Metadata Standard (IEEE LTSC, 2005). Moreover, by using the eAccess2Learn Accessible Learning Objects Metadata Authoring Toolkit, eTraining Course Suppliers can create and offer descriptions of available eTraining Courses with emphasis to accessibility aspects, so as to enable eTraining Services Providers to take more informed decisions during the design of their eTraining Programmes.

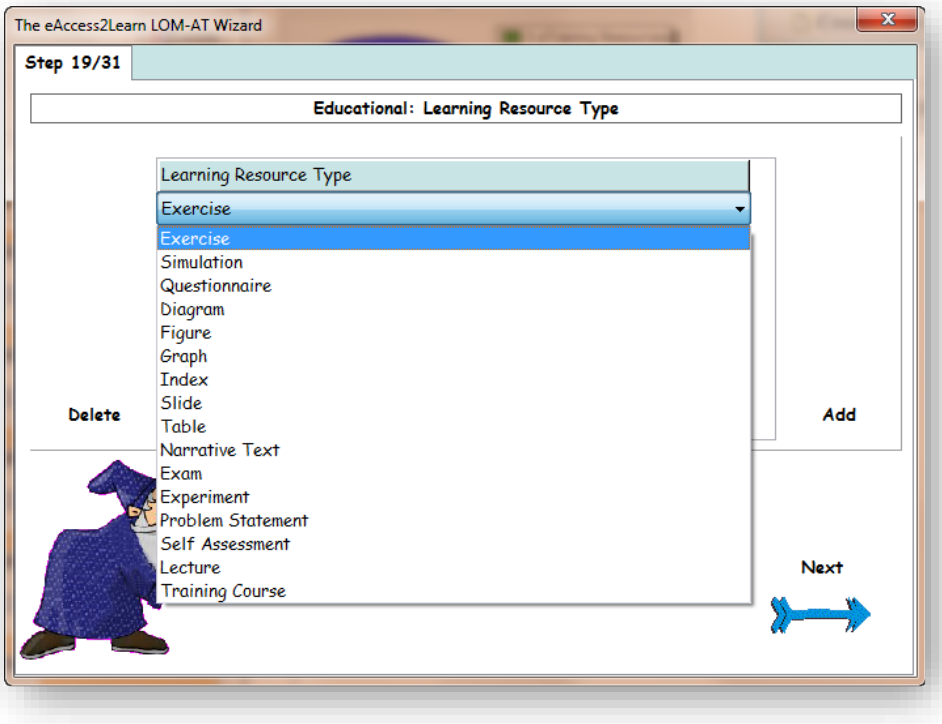


Figure 4.8: Authoring Educational Metadata (learning resource type metadata element) using the Authoring Wizard

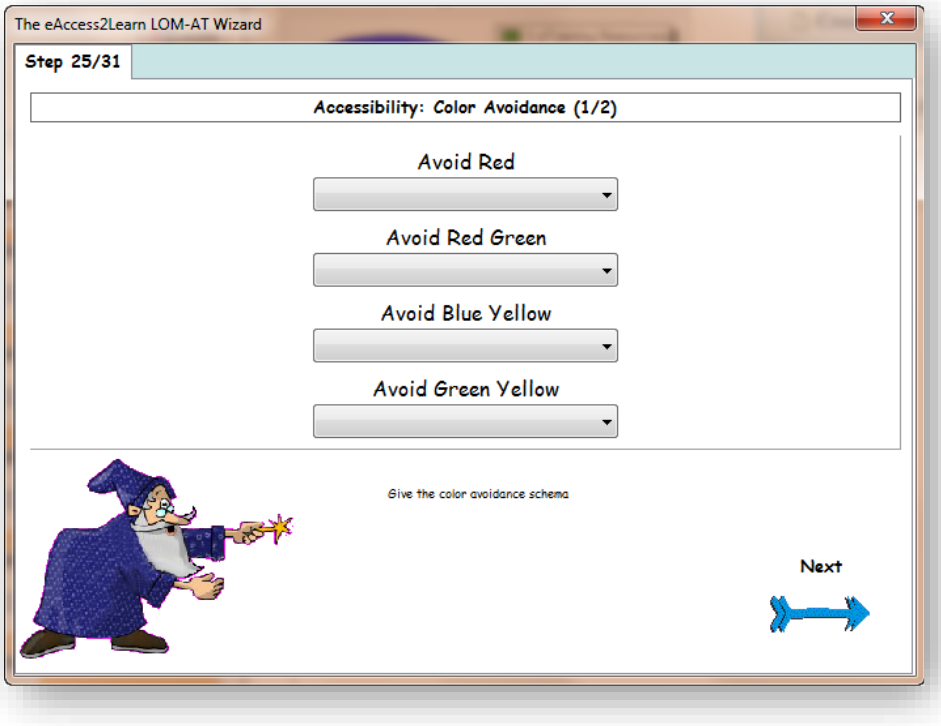


Figure 4.9: Authoring Accessibility Metadata using the Authoring Wizard

In order to handle the accessibility characteristics of the eTraining Resources and Courses, we have proposed extensions to the IEEE LOM standard through an IEEE LOM Application Profile, which was reported in (Sampson et al., 2008). More specifically, we have proposed the extension of the category 4.8 (Technical) with information about the use of colors in learning objects, so as visually impaired people to be able to access appropriately developed eTraining Resources. Table 4-1 summarizes these extensions.

Table 4-1: Extensions of IEEE LOM – Technical Category

Nr	Name	Explanation	Size	Value Space	Datatype
4.8	Color Avoidance	Preferences regarding the use of color in the described learning object	1		
4.8.1	Avoid Red	Indicates that the described learning object avoids red color	1	Yes No	Vocabulary
4.8.2	Avoid Red Green	Indicates that the described learning object avoids red and green colors together	1	Yes No	Vocabulary

4.8.3	Avoid Blue Yellow	Indicates that the described learning object avoids blue and yellow colors together	1	Yes No	Vocabulary
4.8.4	Avoid Green Yellow	Indicates that the described learning object avoids green and yellow colors together	1	Yes No	Vocabulary
4.8.5	Avoid Orange	Indicates that the described learning object avoids orange color	1	Yes No	Vocabulary
4.8.6	Avoid Red Black	Indicates that the described learning object avoids red and black colors together	1	Yes No	Vocabulary
4.8.7	Avoid Purple Grey	Indicates that the described learning object avoids purple and grey colors together	1	Yes No	Vocabulary
4.9	Color Difference	Indicates the maximum contrast in the described learning object	1	0…100	Integer
4.10	Color Brightness	Indicates the color brightness of the colors used in the described learning object	1		
4.10.1	Minimum	Indicates the minimum color brightness of the colors used in the described learning object	1	0…100	Integer
4.10.2	Maximum	Indicates the maximum color brightness of the colors used in the described learning object	1	0…100	Integer

Additionally, we have proposed the extensions to the value space of the metadata element [Kind] in the category 4.7 (Relation) with information about the relationship of eTraining Resources with visual, text or auditory alternatives. Table 4-2 summarizes these value space extensions.

Table 4-2: Extensions of IEEE LOM – Relation Category

Nr	Name	Explanation	Size	Value Space	Datatype
4.7	Relation	This category defines the relationship between this learning object and alternatives learning objects, if any	smallest permitted maximum: 100 items		
4.7.1	Kind	Nature of the relationship between the described learning object and the target learning object	1	ispartof haspart ... hasvisual alternative hastext alternative hasauditory alternative	Vocabulary

4.4.2.4 eAccess2Learn Web Repository

This is a web-based platform enabling the eTraining Content Suppliers and the eTraining Course Suppliers to share their eTraining Resources and eTraining Courses. Moreover, the eAccess2Learn Web Repository (http://www.eaccess2learn.eu/) offers to the eTraining Services Providers the ability to search and retrieve eTraining Courses, which they can integrate to their services. Additionally, the eAccess2Learn Web Repository is conformant with Web Content Accessibility Guidelines 1.0 (W3C, 1999) enabling also direct access from users with certain disabilities, namely, motor disabled and visually impaired users. The functionalities of the eAccess2Learn Web Repository can be summarized as follows:

- **Submit and Store:** eTraining Content Suppliers and eTraining Courses Suppliers are able to submit and store eTraining Resources and Courses to the eAccess2Learn Web Repository along with their related educational metadata, which has been previously developed by using the eAccess2Learning Accessible Learning Objects Metadata Authoring Toolkit.

- **Search and Retrieve:** All user categories of the eAccess2Learn Web Repository are able to search and retrieve eTraining Resources and Courses by using searching criteria, which are matched with the educational metadata of these resources and courses.
- **Download:** All user categories of the eAccess2Learn Web Repository are able to download eTraining Resources and Courses and use them through other eTraining systems and platforms. Moreover, the users are able to download the metadata record of an eTraining Resource or an eTraining Course and import it to other eTraining systems and platforms or repositories, so as to be searchable and retrievable.
- **Rate/Comment:** All user categories of the eAccess2Learn Web Repository are able to provide their ratings and comments for the eTraining Resources and eTraining Courses stored in the eAccess2Learn Web Repository. These ratings and comments could be related with the impressions of the users who have used a specific eTraining Resource/Course.

Figure 4.10, Figure 4.11, Figure 4.12 and Figure 4.13 presents screenshots of the eAccess2Learn Web Repository functionalities. More precisely, the searching mechanism of the eAccess2Learn Repository is presented, where the users can search eTraining Resources and Courses by using searching criteria, which are matched with the educational metadata of these resources and courses. Next, the searching results are presented, where the users can browse and download eTraining Resources and Courses by previewing their educational metadata. The next screenshot presents the uploading mechanism of the eAccess2Learn Web Repository, where the users (eTraining Content Suppliers and eTraining Courses Suppliers) can upload their eTraining Resources and Courses along with their related educational metadata records, so as to be searchable and retrievable from the searching mechanism of the repository. Finally, the last screenshot presents the rating/commenting mechanism, where the users can (a) provide their ratings and comments about eTraining Resources and Courses included in the eAccess2Lern Web Repository and (b) browse the ratings and comments of other users of the eAccess2Learn Web Repository.

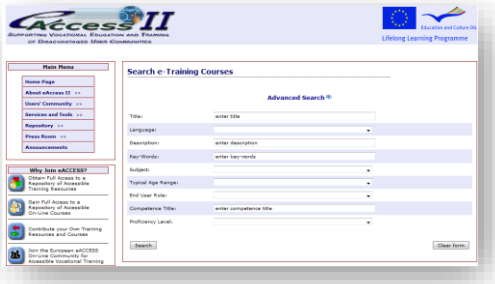


Figure 4.10: Searching Mechanism for eTraining Resources/Courses

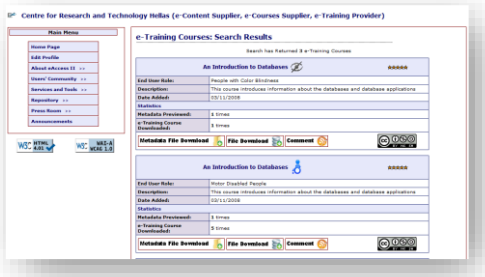


Figure 4.11: Browse and Download eTraining Resources/Courses from eAcces2Learn Web-Repository

Figure 4.12: Submit and Store eTraining Resources/Courses to eAcces2Learn Web-Repository

Figure 4.13: Submit and Store eTraining Resources/Courses to eAcces2Learn Web-Repository

4.5 Experimental Results

In this section, we present experiments for evaluating the customized hierarchical framework. More specifically, the main objectives that we aim to address though these experiments are the following:

- **Objective 1:** To validate the transformation of existing eTraining Resources to fully accessible for both selected disabled user groups by using the eAccess2Learn Guidelines for Developing Accessible Web-Based Training Content.
- **Objective 2:** To validate the transformation of the presentation of the same eTraining Resources with the use of the eAccess2Learn Accessibility Style Sheets for Developing Accessible Web-Based Training Content so as to be understandable and navigable for both selected disabled user groups.

- **Objective 3:** To validate the interoperability of the educational metadata of the eTraining Resources and Courses produced by the eAccess2Learn Accessible Learning Objects Metadata Authoring Toolkit.
- **Objective 4:** To validate the interoperability of the eTraining Courses produced by the eAccess2Learn Learning Design Toolkit.
- **Objective 5:** To validate the reuse of eTraining Re-sources within different eTraining Courses produced by using the eAccess2Learn Framework Tools.
- **Objective 6:** To validate the reuse of the eTraining Course Templates within different eTraining Courses, as well as among different disabled user groups (namely, motor disabled and low vision people) by using the eAccess2Learn Framework Tools.

First, the services and tools of the eAccess2Learn Framework was used by twenty six (26) eTraining Content Suppliers, during specially designed 2-days workshops, which were held in four (4) Vocational Education and Training (VET) Organizations located in four (4) European countries, that is Greece, Romania Bulgaria and Cyprus. Each participated eTraining Content Supplier developed thirty (30) accessible eTraining Resources (in the form of HTML pages) for each disabled user group (by using the eAccess2Learn Guidelines and Style Sheets for Developing Accessible Web-Based Training Content) and authored educational metadata for these eTraining Resources (by using the eAccess2Learn Accessible Learning Objects Metadata Authoring Toolkit), producing a total of 780 eTraining Resources for each disabled user group (namely, motor disabled and low vision people). More specifically, the steps that were followed during the workshops are presented below and they are depicted in Figure 4.14 as a workflow diagram:

- **Step 1:** During this step, each participant developed thirty (30) accessible eTraining Resources by following the eAccess2Learn Guidelines for Developing Accessible Web-Based Training Content. The outcome of step 1 was 30 accessible eTraining Resources.
- **Step 2:** During this step, each participant validated and corrected the markup html syntax of the developed eTraining Resources using the W3C markup Validation Service.

- **Step 3:** During this step, each participant transformed the presentation of the HTML elements of the 30 developed accessible eTraining Resources by using the eAccess2Learn Accessibility Style Sheets, so as to be understandable and navigable for low vision and motor disabled people, producing 30 accessible eTraining Resources for each disabled user group (60 in total).
- **Step 4:** Finally, each participant characterized with educational metadata the developed accessible eTraining Resources for both disabled user groups and uploaded them to the eAccess2Learn Web Repository by using the uploading mechanism of the repository.

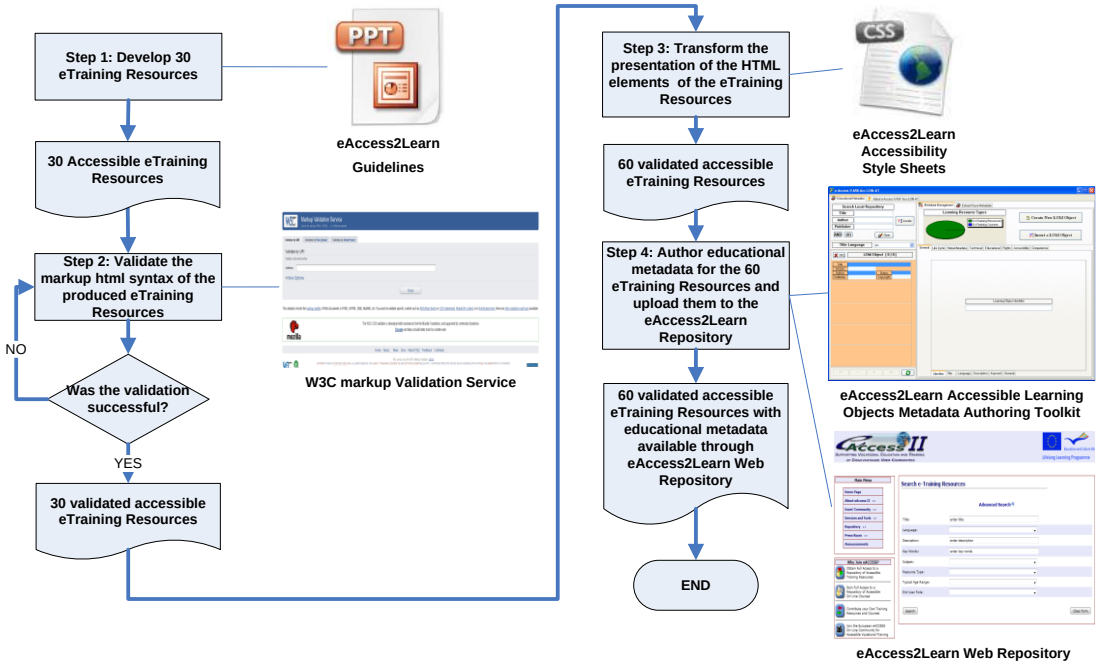


Figure 4.14: Workflow Diagram of the steps followed by each participant during the workshops with the eTraining Content Suppliers

After the end of the workshops, we validated the accessibility conformance (addressing objective 1) of the produced eTraining Resources using an automated accessibility validation tool, namely, the IBM's aDesigner (http://www.alphaworks.ibm.com/tech/adesigner). All produced eTraining Resources (780 in total) passed the accessibility validation against the W3C Web Content Accessibility Guidelines 1.0. These validation results provided us strong indications that the eAccess2Learn Guidelines for Developing Accessible Web-Based

Training Content could be successfully applied for the transformation of existing eTraining Resources to fully accessible for motor disabled and low vision people.

After that, we asked 32 motor disabled people and 32 low vision people, to review fifty (50) eTraining Resources per disabled user group, so as to receive their feedback about the transformation of the HTML content of the produced eTraining Resources when the eAccess2Learn Style Sheets are applied (addressing objective 2). More precisely, we asked them to complete appropriately designed questionnaires with questions investigating their satisfaction about the presentation, the undestandability and the navigability of the HTML elements (e.g. text size/colour, foreground/background colour, buttons, links etc) of the produced eTraining Resources. For each question a five-point likert scale was used where 5 denotes "very satisfied" and 1 denotes "not at all satisfied". Table 4-3 presents the mean ranking for each disabled user group for different categories of satisfaction. These categories were selected from the different themes of accessible design that the Web Content Accessibility Guidelines addresses (W3C, 1999; W3C, 2008), as explained in Section 4.4.2.2.

Table 4-3: Mean Ranking of eTraining Resources Validation by two (2) Disabled User Groups

Disabled User Group	Satisfaction		
	Presentation	Undestandability	Navigability
Motor Disabled	4,86	4,92	5
Low Vision	4,76	4,87	5

The next experiment conducted was designed to validate the interoperability (addressing objective 3) of the produced educational metadata records of the eTraining Resources produced. For this purpose, we used two (2) well known educational metadata editors which conform to the IEEE LOM Standard, namely, were the Reload Metadata Editor (http://www.reload.ac.uk/) and the LomPad tool (http://helios.licef.ca:8080/LomPad/en/index.htm), and we imported the produced

XML metadata records to these tools. All 780 eTraining Resources educational metadata records were imported correctly to both the Reload Metadata Editor and the LomPad tool. The validation results provided us evidences that the educational metadata records of the produced eTraining Resources retain their interoperability with other educational metadata editors, which conform to the IEEE LOM Standard.

Next, the services and tools of the eAccess2Learn Framework were used by twenty one (21) eTraining Courses Suppliers, during specially designed 2-day workshops, which were also held in the same VET Organizations described before. Each participated eTraining Courses Supplier developed; using the eTraining Resources previously produced and uploaded to the eAccess2Learn Web-Repository, five (5) eTraining Courses for each disabled user group (namely, motor disabled and low vision people) by using the eAccess2Learn Learning Design Toolkit. More specifically, the steps that were followed during the workshops are presented below and they are depicted in Figure 4.15 as a workflow diagram:

- **Step 1:** First, each participant selected one (1) eTraining Course Template from the reference set of eTraining Course Templates (developed by typical eTraining Course Suppliers based on their best practices), which are embedded in the eAccess2Learn Learning Design Toolkit, so as to develop his/her eTraining Courses based on that template. The selection of the eTraining Course Template from each participant was based on the following criteria: (a) the conformance of the eTraining Course Templates educational objectives with the educational objectives that each participant was aiming to address with its eTraining Courses, and (b) the accessibility needs of the two targeted disabled user group.
- **Step 2:** Next, each participant used the searching mechanisms of the eAccess2Learn Repository, so as to search and retrieve appropriate eTraining Resources suitable for (a) the learning activities of the selected eTraining Course Template, (b) the accessibility needs of each disabled user group and (c) the subject domains that have been selected by each participant for the development of their eTraining Courses.

- **Step 3:** During this step, each participant used the eAccess2Learn Learning Design Toolkit, to produce five (5) eTraining Courses, represented in the form of IMS Learning Design Packages for each of the two disabled user group, based on the selected eTraining Course Template and the eTraining Resources selected from the eAccess2Learn Web Repository.
- **Step 4:** Finally, each participant characterized with educational metadata the developed eTraining Courses for the two disabled user groups and uploaded them to the eAccess2Learn Web Repository by using the uploading mechanism of the repository.

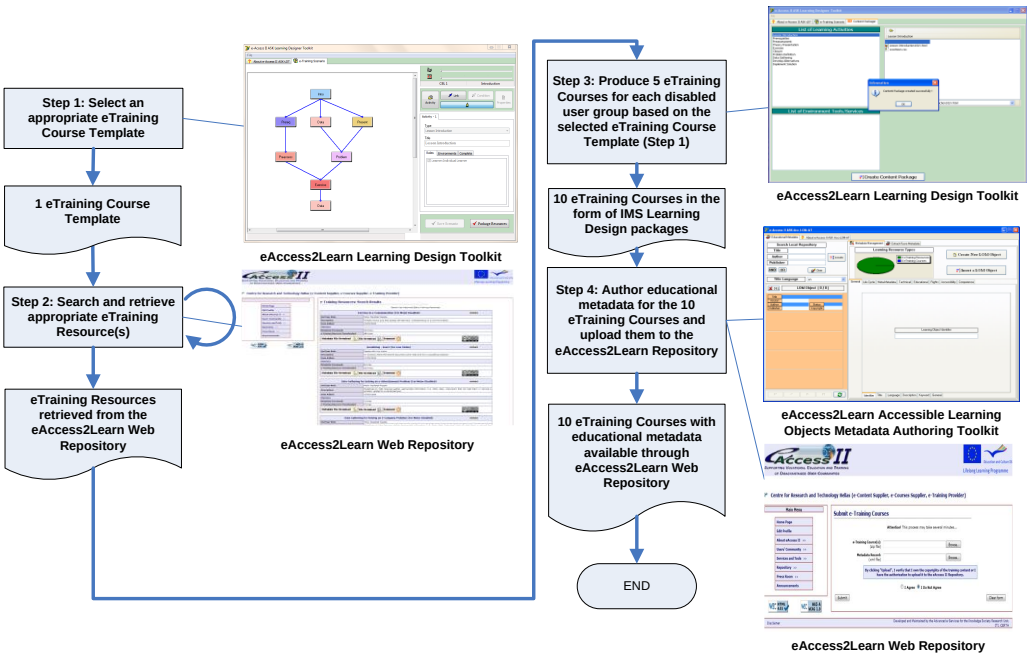


Figure 4.15: Workflow Diagram of the steps followed by each participant during the workshops with the eTraining Courses Suppliers

After the end of these workshops, we validated the interoperability (addressing objective 3) of the produced educational metadata records of the eTraining Courses produced by following the procedure described before. All 105 eTraining Courses educational metadata records were imported correctly to the Reload Metadata Editor, as well as, to the LomPad tool. The validation results provided us evidences that the educational metadata records of the produced eTraining Courses retain their interoperability with other educational metadata editors, which conform to the IEEE LOM Standard.

Furthermore, we validated the interoperability of the produced eTraining Courses with other learning design tools (addressing objective 4), which conform to the IMS Learning Design Specification. The tools, which were selected for this purpose, were the ReCourse Learning Design Editor (http://tencompetence-project.bolton.ac.uk/ldauthor/index.html) and the Reload Learning Design Player (http://www.reload.ac.uk/ldplayer.html). All 105 eTraining Courses were correctly imported to both the ReCourse Learning Design Editor and the Reload LD Player. The validation results provided us evidences that the produced eTraining Courses retain their interoperability with other learning design tools, which conform to the IMS Learning Design Specification.

The next experiment was designed to measure the reuse of the eTraining Resources (addressing objective 5) within the eTraining Courses produced for the two disabled user groups. In order to measure that, we searched for common pre-existing eTraining Resources (that is, reused within two or more eTraining Courses) and for unique pre-existing eTraining Resources (that is, used only in one eTraining Course). Table 4-4 presents the reuse results of the eTraining Resources and the reuse percentage according to the total number of eTraining Resources developed for each of the two disabled user group.

Table 4-4: Reuse of eTraining Resources

Disabled User Group	eTraining Resources			Reuse percentage
	Total	Common Resources	Unique Resources	
Motor Disabled	780	214	566	27,43%
Low Vision	780	267	513	34,23%

As we can notice from Table 4-4, 27,43% of the total eTraining Resources, developed for motor disabled people, were reused within two or more eTraining Courses for this disabled user group. Additionally, 34,23% of the total eTraining Resources, developed for low vision people, were reused within two or more eTraining Courses for this disabled user group. These results provided us evidences that the proposed eAccess2Learn Framework can facilitate the process of re-using eTraining Resources

within different eTraining Courses, which are addressing a specific disabled user group.

The final experiment was to measure the reuse of the eTraining Course Templates within different eTraining Courses, as well as among the two disabled user groups (addressing objective 6). In order to measure that, we searched through the 210 eTraining Courses developed (a) for the same disabled user group and (b) for both disabled user groups, so as to identify the number of eTraining Courses, which were designed, based on common eTraining Course Templates (that is, reused within two or more eTraining Courses), as well as, based on unique eTraining Course Templates (that is, used only in one eTraining Course). Table 4-5 and Table 4-6 present the reuse results of the eTraining Courses according to the eTraining Course Templates that they have been based upon.

Table 4-5: Reuse of eTraining Course Templates within Different eTraining Courses

Disabled User Group	eTraining Courses			Reuse percentage
	Total	Developed based on common eTraining Course Template(s)	Developed based on unique eTraining Course Template(s)	
Motor Disabled	105	105	0	100,00%
Low Vision	105	105	0	100,00%

Table 4-6: Reuse of eTraining Course Templates among Different Disabled User Groups

eTraining Courses			Reuse percentage
Developed for the two disabled user groups	Developed based on common eTraining Course Template(s)	Developed based on unique eTraining Course Template(s)	
210	148	62	70,47%

As we can notice from Table 4-5, all eTraining Course Templates were reused within the eTraining Courses developed for the same disabled user group. On the other

hand as shown in Table 4-6, 70,47% of the eTraining Courses developed for both disabled user groups were based on common eTraining Course Templates, and only 29,53% of these courses required unique eTraining Course Templates. This means that the majority of the eTraining Course Templates were suitable for both disabled user groups and can be reused among them for the design and development of eTraining Courses.

4.6 Conclusions

In this chapter, we customized the hierarchical framework (presented in section 2.3), in order to support the main stages of the e-Learning chain, namely, creation, publication, discovery, acquisition, access, use and reuse of accessible digital training resources and courses, while retaining their interoperability between various eTraining Systems and Platforms.

A number of experiments for evaluating the customized hierarchical framework in two different disabled user groups, namely motor disabled and low vision people, provided us solid indications that:

- Existing eTraining Resources can be transformed to accessible, so as to be understandable and navigable for the two disabled user groups.
- Existing eTraining Resources can be reused within different eTraining Courses, while retaining their interoperability between various eTraining Systems and Platforms.
- Existing eTraining Course Templates can be reused within different eTraining Courses, as well as, among different disabled user groups (in our case, the motor disabled and the visually impaired people).

In the next chapter, we perform an additional customization of the hierarchical framework towards supporting open access and reuse to Mobile Assisted Language Learning.

5 Applying the Proposed Hierarchical Framework for Supporting Open Access and Reuse to Mobile Assisted Language Learning[8]

5.1 Introduction

Language learning has been a primary field of application of mobile learning, which is defined as the process of learning and teaching that occurs with the use of mobile devices providing flexible on-demand access (without time and device constraints) to learning resources, experts, peers and learning services from any place (Sharples & Roschelle, 2010; Traxler, 2009). This has led to the development of a new approach for Technology-enhanced Language Learning (TELL) which is commonly referred to as Mobile Assisted Language Learning (MALL). MALL is typically defined as "*an approach to language learning that is assisted or enhanced through the use of a handheld mobile device*" (Valarmathi, 2011). As a result, a number of MALL systems have been proposed such as CAMLES (Nguyen & Pham, 2012), TAMALLE+ (Fallahkhair, 2012), JAPELAS2 (Yin et al., 2010) and PALLAS (Petersen & Markiewicz, 2008), aiming to investigate the potential advantages of using mobile devices in language learning.

On the other hand, the emerging OERs initiatives have enabled teachers to organize, classify and store digital educational resources and their associated metadata in web-based repositories towards facilitating their sharing and reuse by other teachers (Friesen, 2009; Lane & McAndrew, 2010). These initiatives have also influenced the field of TELL and some web-based open access repositories have been recently developed towards supporting open access, sharing and reuse of digital language learning resources. However, these repositories do not include digital language learning resources that can be delivered to mobile devices for supporting MALL. Additionally, these repositories do not put emphasis on the reuse of digital language learning resources and there is limited evidence about the factors that could influence and possibly enhance reuse of educational resources in the field of

[8] This chapter is an adapted copy of the following published journal paper:

P. Zervas and D. Sampson, "Facilitating Teachers' Reuse of Mobile Assisted Language Learning Resources using Educational Metadata", IEEE Transactions on Learning Technologies, IEEE Computer Society, (in press), http://dx.doi.org/10.1109/TLT.2013.39

Language Learning, as well as in the field of MALL. As a result, it is worthy to investigate technology-supported solutions that can support open access and reuse of MALL resources. Within this context, in this chapter we customize and extend the hierarchical framework (defined in section 2.3) for supporting open access and reuse to MALL. Moreover, a quantitative analysis of the reuse of MALL resources developed with the customized Framework, namely the Mobile2Learn Framework is conducted.

The chapter is organized as follows: First, we discuss existing efforts in the OERs area for supporting open access and reuse of MALL resources and we identify the limitations of current practices. Next, we describe the customization of the hierarchical framework for facilitating open access and reuse to MALL resources within the context of MALL courses design and development and we present the tools of the proposed framework with emphasis on the educational metadata aspects of the framework. Afterwards, we conduct a quantitative analysis of the reuse of MALL resources within MALL courses developed with the customized hierarchical framework tools and we discuss the results of our study.

5.2 Open Access and Reuse of MALL Resources

Over the past years a number of web-based open ac-cess repositories with digital language learning resources have been developed such as:

- **The FLORE Repository** (http://flore.uvic.ca/), which was developed by the "French Learning Object Repository for Education" project and provides open access to digital resources for teaching French as second language (Caws et al., 2006).
- **The Tutela Repository** (Tutela, http://tutela.ca/), which has been funded by Citizenship and Immigration Canada and provides open access to digital resources for teaching Canadian English and French as second language.
- **The Languages Open Resources Online Repository** (LORO, http://loro.open.ac.uk/), which was developed by Department of Languages at the UK Open University and provides open access to digital resources for teaching a variety of languages.

- **The Language Box** (http://languagebox.ac.uk), which was developed by the Faroes project and provides open access to digital resources for a wide variety of languages at various levels (Borthwick et al., 2009).
- **The SPEAKAPPS Repository** (http://oer.speakapps.org/), which was developed by the EU-funded SPEAKAPPS Project and provides open access to digital resources for a wide variety of languages at various levels (Appel et al., 2012).

These repositories are mainly used by foreign language teachers for: (a) searching and reusing digital language learning resources for their teaching activities and (b) sharing their digital language learning resources with other foreign language teachers. An important factor, in order to facilitate foreign language teachers in the process of searching, retrieving and reusing digital language learning resources, is the existence of educational metadata for these resources. The dominant metadata standard for characterizing educational resources with metadata is the IEEE Learning Object Metadata (IEEE LOM) Standard (IEEE LTSC, 2005). FLORE Repository and Tutela Repository adopt the IEEE LOM standard for characterizing their language learning resources, whereas LORO Repository adopts Dublin Core Metadata Element Set (DCMI, 2005) and Language Box Repository and SPEAKAPPS Repository adopt their own metadata model. However, the majority of the examined repositories do not put emphasis on specific metadata for describing the language learning characteristics of their language learning resources. More specifically, language learning resources stored in most of these repositories cannot be searched and retrieved based on the particular language learning objectives they address. Moreover, although all examined repositories support open access to language learning resources, these resources have not been designed by following the W3C Mobile Web Best Practices (Rabin & McCathieNevile, 2008). As a result these resources will not have an optimum performance when delivered to mobile devices in terms of page layout and content, navigation and links, as well as user input.

On the other hand, the issue of whether language learning resources are reused and how, seems to be an important one for the existing language learning repositories. More specifically, recent studies by Pulker & Calvi (2013), by Beaven (2013), as well

as by Comas-Quinn et al. (2013) have investigated, focusing on the LORO Repository, the type of changes made to language learning resources when reused and the reasons for these changes. Nevertheless, these studies do not provide metrics for measuring reuse of language learning resources stored in LORO Repository or in others existing language learning repositories, in general. Consequently, there is no experimental evidence about the possible factors that can influence and possibly enhance reuse of educational resources in the field of Language Learning, as well as in the field of MALL.

Next, we address these issues by customizing and extending the hierarchical framework (defined in section 2.3) for supporting open access and reuse to MAL resources within the context of MALL courses design and development.

5.3 Customizing and Extending the Proposed Hierarchical Framework

5.3.1 User Roles

The customized hierarchical framework (namely, Mobile2Learn Framework) identifies three (3) main user roles in MALL, as follows:

- **MALL Content Suppliers**, that is, the role responsible for designing and developing MALL resources in the form of LOs. The MALL Content Suppliers need to be able to (a) convert their existing digital language learning resources and/or create new digital language learning resources that meet mobile delivery requirements and (b) characterize these resources with metadata that are meaningful in relation to the MALL characteristics of the resources. Thus, the hierarchical framework has been customized to provide them with a set of guidelines (based on the W3C Mobile Web Best Practices 1.0) and the technological means (namely, a metadata authoring toolkit, described in section 5.3.2.2) for developing MALL resources and tagging them with appropriate educational metadata based on an appropriate designed LOM application profile (described in section 5.3.2.2).
- **MALL Courses Suppliers**, that is, the role responsible for designing MALL courses based on a pre-defined sequence of learning activities (in our work, referred to as course template) which represents the adopted language

teaching practice as a workflow. For the purposes of the customized framework a MALL course is defined as: a sequence of learning activities populated with MALL resources (Alonso et al., 2005) conducted entirely via a mobile device, targeting specific educational objectives and with duration of 8 to 16 teaching hours in total. Moreover, a MALL course template is defined as: a sequence of generic learning activities representing a specific MALL teaching practice (McAlpine & Allen, 2007), which potentially can be populated with different MALL resources for developing different MALL courses. Thus, the hierarchical framework has been customized to provide to the MALL Courses Suppliers with a methodology and the technological means (namely a course authoring toolkit described in section 5.3.2.1) for defining their MALL teaching practices and for representing them in a common machine understandable format following the IMS Learning Design (LD) specification (IMS GLC, 2003a). Furthermore, the Mobile2Learn Framework provides them with a set of indicative examples of MALL course templates representing specific MALL teaching practices, which they can use and modify. Finally, it offers them access to a web-based repository of MALL Resources (in the form of LOs characterized with appropriate educational metadata) to facilitate them in the design and the development of their MALL courses.

- **MALL Services Providers**, that is, the role responsible for designing MALL programs as a synthesis of MALL courses and delivering them to their students. Thus, the hierarchical framework has been customized to provide them with (a) access to a repository of MALL courses (represented in the form of IMS Learning Designs) which they can use to search and retrieve MALL courses and (b) the technological means (namely, a course delivery tool) for delivering MALL courses to their students via mobile devices.

Figure 5.1 presents the identified user roles, their interconnections, as well as, their needs and the tools/services that the customized hierarchical framework offers them to support these needs.

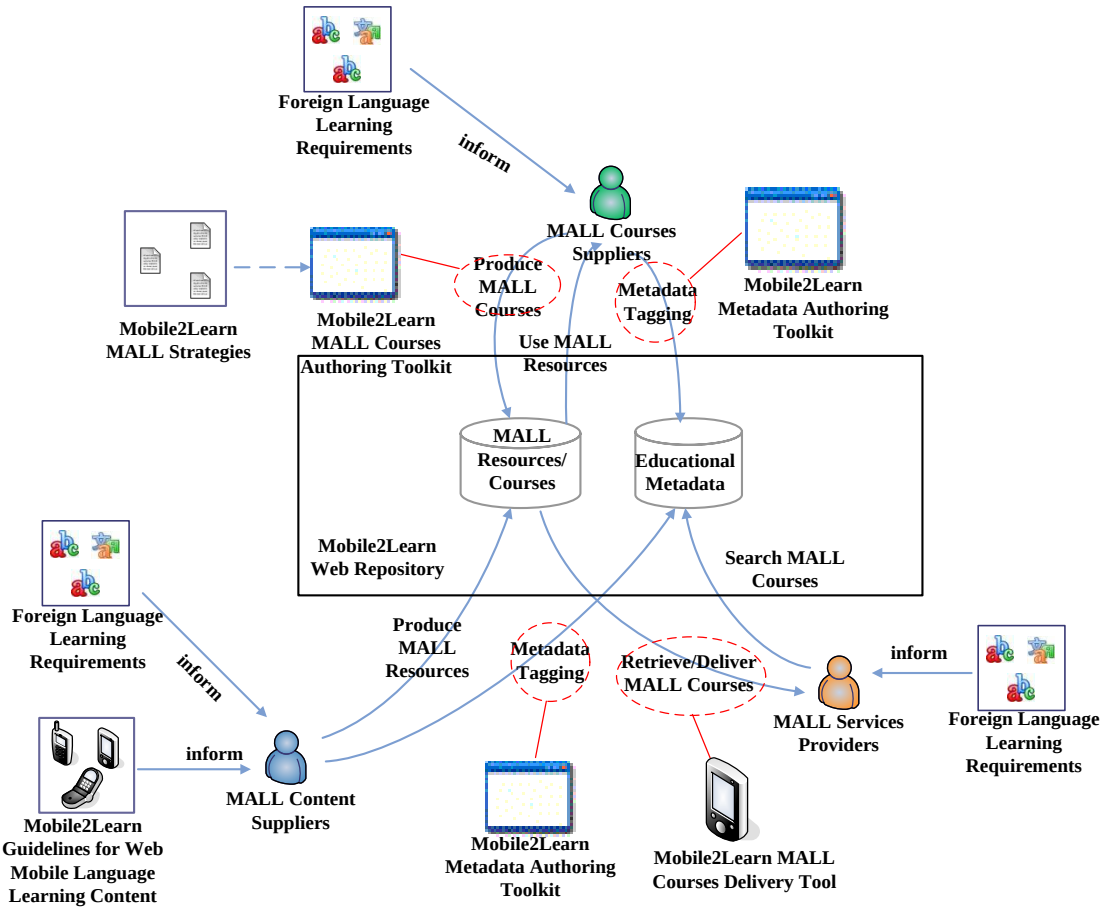


Figure 5.1: The Customized Hierarchical Framework (namely, Mobile2Learn Framework) for Supporting Open Access and Reuse to MALL

5.3.2 Tools and Services

The Mobile2Learn framework provides to the main user roles identified in section 5.3.1, a set of key services and tools that are described next in details.

5.3.2.1 Mobile2Learn MALL Courses Authoring Toolkit for Designing MALL Course Templates and MALL Courses

This is a customized version of the ASK-LDT Tool that has been presented in section 2.3.3.4. It has been customized to enable MALL Courses Suppliers (a) to express their MALL teaching practices, in the form of MALL course templates, using a common machine understandable way, and (b) to design and develop MALL courses using a reference set of pre-defined MALL course templates. As a result, a set of MALL course templates, which represent different MALL teaching practices, can be designed to facilitate the development of MALL courses that adopt these practices. Figure 5.2 presents a snapshot of the Mobile2Learn MALL Courses Authoring Toolkit,

which provides MALL Courses Suppliers with a graphical interface for creating MALL courses conformant with the IMS LD Specification and packaging them along with their related MALL resources.

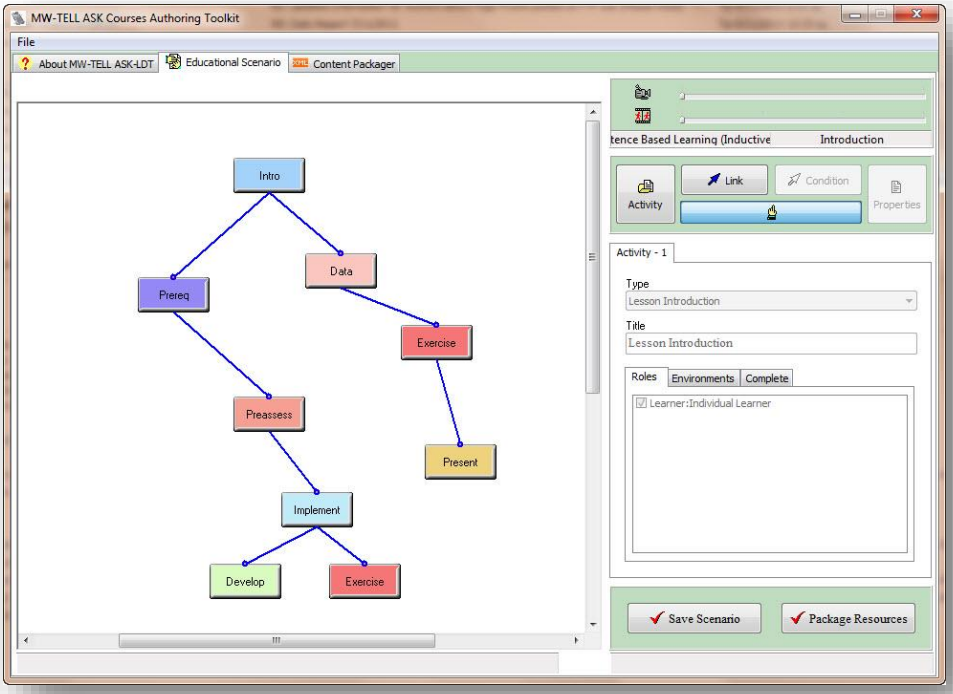


Figure 5.2: Creating a new MALL course based on a pre-defined MALL course template

5.3.2.2 Mobile2Learn Metadata Authoring Toolkit

This is a customized version of the ASK-LOM-AT 2.0 Tool that has been presented in section 2.3.3.1. It has been customized to allow MALL Content Suppliers and the MALL Courses Suppliers to author educational metadata for their MALL resources and courses, as well as, to organize and offer MALL resources and courses through the Mobile2Learn Web Repository. Educational metadata describe the different characteristics and attributes of a MALL resource or course, e.g. title, description, keywords, target user group or subject domain. They are made up of data items that are associated with a MALL resource or course, which are called metadata elements. Each MALL resource or course is associated with a metadata record composed by metadata elements with specific values. The more complete a metadata record is, better informed decisions can be taken by MALL Courses Suppliers and MALL

Services Providers, when searching to (re)use MALL resources and MALL courses correspondingly.

The Mobile2Learn Metadata Authoring Toolkit offers an authoring wizard for describing MALL resources and courses with educational metadata conformant with IEEE LOM standard. However, it is beyond the scope of IEEE LOM to directly support the description of characteristics related with MALL. As a result, in order to handle the specific characteristics of the MALL resources and courses, extensions have been implemented to the value space of the IEEE LOM Classification Category (Nr. 9) through a LOM Application Profile, proposed in Zervas & Sampson (2010). More specifically, two controlled vocabularies have been introduced for the sub-element "Taxon Path.Taxon.Entry (Nr. 9.2.2.2)" based on the different values that the sub-element "Purpose (Nr. 9.1)" takes, as described below:

- When the value is "educational objective" then the purpose of the Classification Element (Nr. 9) is to define the educational objectives that a learning object is targeting. As a result, in the sub-element Taxon Path.Source we can use the "CEFR Levels" value to state that the educational objectives are derived from those defined in Common European Framework of Reference for Languages: Learning, Teaching, Assessment (CEFR) which is a framework used to describe achievements of learners in foreign languages across Europe (Council of Europe, 2001). CEFR provides six reference levels, which are becoming widely accepted as the European standard for grading an individual's language proficiency, adopted also from the Europass Language Portfolio (Little, 2002). These six levels are (Council of Europe, 2001): (a) Basic User: A1 and A2, (b) Independent User: B1 and B2 (c) Proficient User: C1 and C2. As a result, the sub-element "Taxon Path.Taxon.Entry" can take these values. Figure 5.3 presents the process of characterizing a MALL resource or course based on the CEFR educational objectives addressed.
- When the value is "accessibility restrictions" then the purpose of the Classification Element (Nr. 9) is to define the accessibility restrictions, which need to be followed so that the learning object can be properly delivered through a specific mobile device. As a result, in the sub-element Taxon

Path.Source we can use the "Screen Resolution" value to state the accessibility requirements for the screen resolution of the mobile device to be used for the proper delivery of the learning object and in the sub-element "Taxon Path.Taxon.Entry" we can use the values of different mobile devices screen resolutions. Figure 5.4 presents the process the process of characterizing a MALL resource or course according to the screen resolution of the mobile device that is going to be delivered.

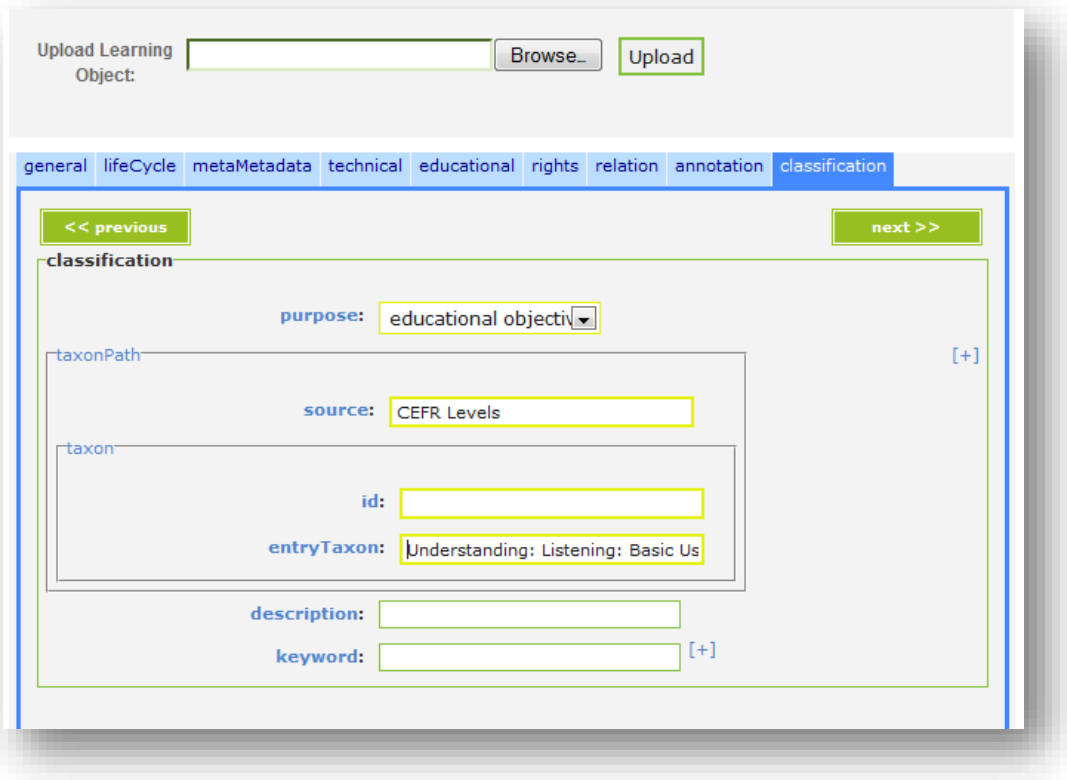


Figure 5.3: Authoring Metadata related with CEFR educational objectives

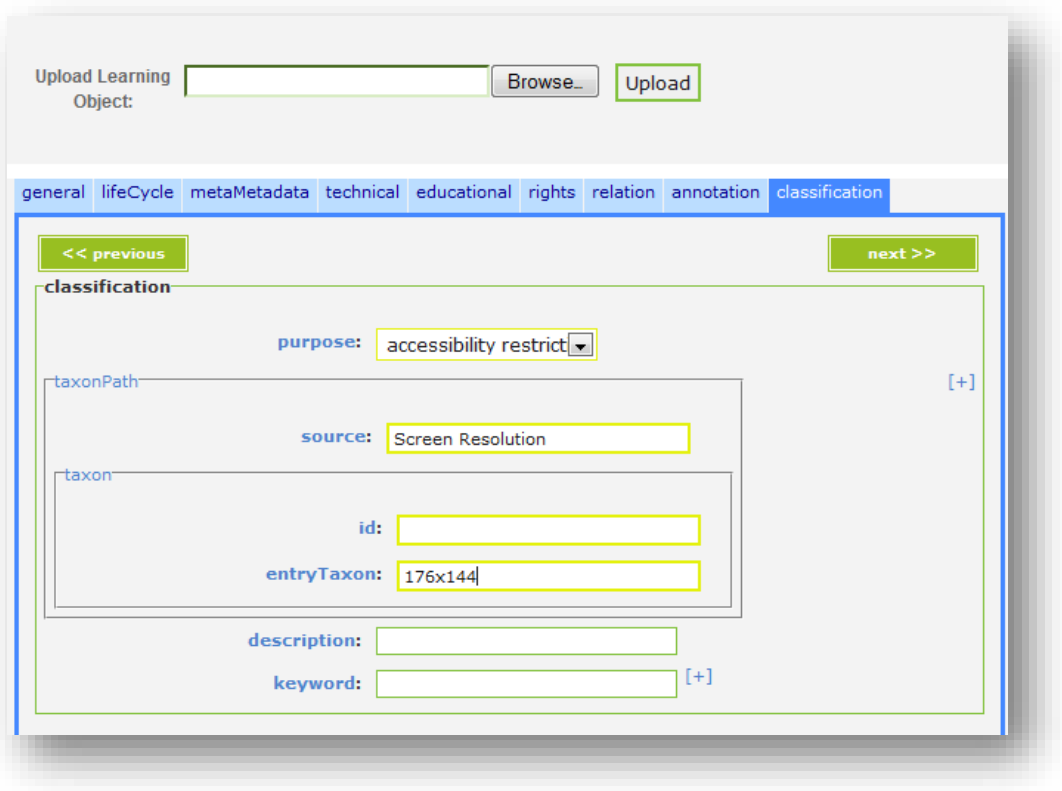


Figure 5.4: Authoring Metadata related with Mobile Devices Characteristics

5.3.2.3 Mobile2Learn Web Repository

This is a web-based platform enabling the MALL Content Suppliers and the MALL Courses Suppliers to share their MALL resources and courses. Moreover, the Mobile2Learn Web Repository (http://www.mobile2learn.eu/) provides the MALL Services Providers with the possibility to search and retrieve MALL courses that can be integrated to their educational offers.

The functionalities of the Mobile2Learn Web Repository can be summarized as follows:

- **Submit and Store:** MALL Content Suppliers and MALL Courses Suppliers are able to submit and store MALL resources and courses to the Mobile2Learn Web Repository along with their related educational metadata, which has been previously developed by using the Mobile2Learn Metadata Authoring Toolkit.

- **Search and Retrieve:** All user roles of the Mobile2Learn Web Repository are able to search and retrieve MALL resources and courses by using searching criteria, which match with the educational metadata of these resources and courses (see Figure 5.5). More specifically, the search form includes searching elements according to the CEFR levels and the screen resolution of the mobile device (as described in section 5.3.2.2), as well as other searching elements, which are mapped to metadata elements provided by the IEEE LOM standard.
- **Rate/Comment:** All user roles of the Mobile2Learn Web Repository are able to provide their ratings and comments for the MALL resources and courses stored in the Mobile2Learn Web Repository. These ratings and comments are typically related with the impressions of the users who have used a specific MALL resource/course.

Figure 5.5: Searching Mechanism for MALL Resources/Courses

5.3.2.4 Mobile2Learn MALL Courses Delivery Tool

This is a customized version of the ASK-Mobile-LD-Player that has been presented in section 2.3.3.5. It has been customized to facilitate MALL Services Providers to deliver to their students MALL courses that have been retrieved from the Mobile2Learn Web Repository. Figure 5.6 and Figure 5.7 present snapshots of the Mobile2Learn MALL Courses Delivery Tool, a platform for delivering MALL courses, which are conformant with the IMS LD Specification (Sampson et al., 2007). Furthermore, the Mobile2Learn MALL Courses Delivery Tool enables enrolment of multiple roles/actors (individual learners, groups of learners and teachers), as well as rendering of HTML-based content and flash files.

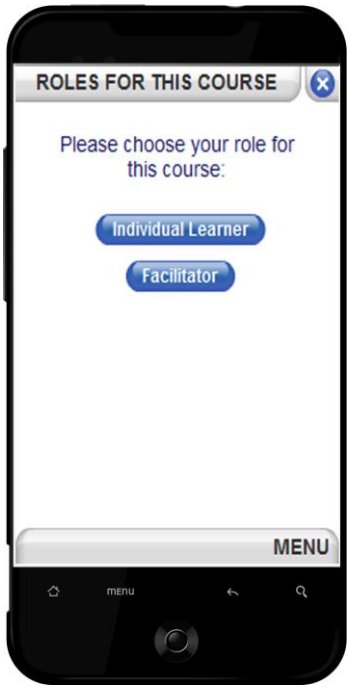


Figure 5.6: Selecting a role for participating to a MALL Course

Figure 5.7: Rendering MALL Resources of a MALL Course

5.4 Quantitative Analysis of MALL Resources Reuse

In this section, we present a quantitative analysis of the reuse of MALL resources within the Mobile2Learn Framework. First, related work is introduced regarding similar studies focused on LOs reuse. Then, the research questions and the adopted research method are described. Finally, the results are outlined.

5.4.1 Related Work

Within the TeL literature, there are existing works that have studied the issue of measuring LOs reuse for different datasets (Vuorikari & Koper, 2009). Koper (2003) has defined three levels of LOs reuse, as follows:

- **First level reuse:** the creator of the LO reuses it to construct another LO of higher granularity.
- **Second level reuse:** a member of a community reuses a LO created by someone else within the same community.
- **Third level reuse:** a member of a community reuses a LO created by someone who is not a member of this community.

Ochoa (2008) has conducted a quantitative analysis of LOs reuse in ARIADNE Repository (http://ariadne.cs.kuleuven.be/finder/ariadne/). Within this study, the reuse was considered to take place at second level, as defined by Koper (2003). The total reuse percentage was calculated around 22% across learning objects of different granularity. This percentage was calculated as the number of LOs that have been reused by any user within LOs of higher granularity compared to the total number of LOs in the repository. Additionally, within this study it was analyzed whether LOs popularity (regarding how many times a LO has been accessed) can influence the LOs reuse. The analysis was based on calculating the Kendall's tau correlation coefficient between the rank of the LO in the reuse and its popularity scale. The results of the study revealed that there was no correlation between the popularity of a LO and the number of times that it has been reused.

Other similar studies have been conducted by Petrides et al. (2008) and Duncan (2009), who have also studied LOs reuse in Connexions Repository (http://cnx.org/). Within both studies, the reuse was considered taking place at second level, as defined by Koper (2003). A similar approach to Ochoa (2008) was adopted and a reuse percentage was calculated around 20,50% across learning objects of different granularity. Furthermore, Duncan (2009) analyzed whether the age of the LOs and the number of keywords available in the metadata of the LOs can influence the LOs reuse. The analysis was based on the Pearson's correlation coefficient between the

rank of the LO in the reuse and its age, as well as the number of keywords assigned to it. The results of the study showed that there was no significant correlation between LOs reuse and their age, as well as their number of keywords.

Finally, Vuorikari and Koper (2009) conducted a similar study and examined LOs reuse in Learning Resource Exchange (LRE) Repository (http://lreforschools.eun.org/) and LeMill (http://lemill.net/) Repository. The reuse was considered as taking place at the second and third levels, as defined by Koper (2003). More specifically, they reported (a) a second level reuse rate of approximately 19% and 22% for LRE Repository and LeMill Repository respectively and (b) third level reuse rate of approximately 12% and 7% for LRE Repository and LeMill Repository respectively. The third level reuse was calculated across communities with users of different spoken languages or different countries of origin. Nevertheless, no evidence was provided within this study about possible factors that could influence the second and/or third levels of LOs reuse.

As a result, it appears, from the aforementioned studies related with LOs reuse in existing repositories, that second level reuse percentage varies from 19% to 22%, whereas third level reuse percentage varies from 7% to 12%. Nevertheless, there is limited evidence about the factors that can influence LOs reuse and achieve reuse percentages higher than previously reported ones. Thus, the main purpose of our study is to measure the reuse of MALL resources within different MALL courses developed with Mobile2Learn Framework Tools and identify empirical evidence about the factors that influence the reuse within Mobile2Learn Framework.

5.4.2 Research Questions

The primary research question that we aim to answer with this study is: "*What are the main factors that influence MALL resources reuse within different MALL courses developed with Mobile2Learn Framework Tools?*" More precise sub-questions related to the primary research question, that could be answered include the following:

1. *What is the percentage of MALL resources reuse at first, second and third level within different MALL courses produced by the Mobile2Learn Framework*? We should mention here that we consider:
    - Second level reuse as taking place among all Mobile2Learn Framework, users (namely, foreign language teachers). This is a key hypothesis in similar studies from the literature (Vuorikari & Koper, 2009; Duncan, 2009; Ochoa, 2008; Petrides et al., 2008; Margaryan & Littlejohn, 2008).
    - Third level reuse as taking place among Mobile2Learn Framework users with different countries of origin. The reason for investigating reuse among users of different country of origin is that cross-country reuse of MALL resources has been a key recent hypothesis in similar studies in the field of technology-enhanced learning (Vuorikari & Koper, 2009) and we considered that it will be worthy to investigate this also in the field of MALL.
2. *Is there a relation between MALL resources reuse at first, second and third level and the level of completeness of MALL resources metadata records?*
3. *Is there a relation between MALL resources reuse at first, second and third level and the number of different metadata values related with CEFR educational objectives added for the Classification metadata element?*

The answers to these questions could facilitate us to compare MALL resources reuse with similar studies (as discussed in section 5.4.1) and identify differences or similarities. Moreover, the study of metadata records completeness versus MALL resources reuse could provide us with evidence whether the information added via metadata to MALL resources can influence their reuse. Additionally, the study of the number of CEFR educational objectives added for the Classification metadata element versus MALL resources reuse could provide us evidence about the validity of our approach for enhancing MALL resources metadata with language learning educational objectives related with CEFR levels (as presented in section 5.3.2.2) towards increasing MALL resources reuse. Finally, we should clarify at this point that only educational metadata records were analyzed, whereas ratings and comments

added by the users of the Mobile2Learn Repository were not considered in this study.

5.4.3 Research Method

5.4.3.1 Participants

The participants who used the Mobile2Learn Framework tools were English language teachers and they were selected based on their previous experience in using ICT tools for foreign language teaching. The participants' average teaching experience with ICT tools was 4.7 years, so they can be characterized as experienced teachers. The participants were engaged in specially designed 5-day workshops, which were held in 4 Vocational Education and Training Organizations (VET) located in four European countries, namely Greece, Czech Republic, Netherlands and Spain. The procedure that was followed was the following:

- *During the workshops*: the participants were trained in the process of using the Mobile2Learn Framework tools. Next, they assumed the role of MALL content suppliers and developed MALL resources, which were characterized with educational metadata (by following the LOM application profile presented in section 5.3.2.2) and uploaded to the Mobile2Learn Repository. The participants chose to create these MALL resources in flash format. The MALL resources were also tailored to meet the specific screen resolution value of the mobile devices handed to them for testing purposes. During this phase, the participants were supervised by the workshops' tutors, who also provided with face to face assistance to the participants for using the Mobile2Learn Framework Tools.
- *After the workshops*: the participants were allowed a three-month period to undertake the role of MALL Courses suppliers and develop MALL courses by using or re-using the MALL resources that were developed by all participants during the four different workshops and were available in the Mobi2Learn Repository. During this process, the participants were also able to develop new MALL resources when existing MALL resources were not suitable to be used in the context of the MALL courses that they were developing. It should

be noted that during this phase the participants were not supervised and they were asked to develop MALL courses on their own. However, they were able to request online technical support by the workshop tutors in case of difficulties with Mobile2Learn Framework Tools.

5.4.3.2 Dataset

Table 5-1 presents the snapshot of the Mobile2Learn Repository which was used for performing our study.

Table 5-1: Description of Mobile2Learn Repository

Users, who created MALL Resources and MALL Courses	112	
Countries of origin of the users, who created MALL Resources and MALL Courses	Greece	33
	Netherlands	27
	Spain	26
	Czech Republic	26
MALL Resources in Repository	719	
MALL Courses in Repository	132	
Date of Dataset	July 2013	

As we can notice from Table 5-1, the total sample of MALL content suppliers and MALL courses suppliers consists of N=112 participants. The countries of origin of the participants were Greece (N=33), Netherlands (N=27), Spain (N=26) and Czech Republic (N=26).

The total number of MALL resources developed was 719 and the total number of MALL courses developed was 132. It is worth mentioning that 582 (80,94%) MALL resources were developed in total during the workshops, whereas 137 (19,06%) MALL resources were developed after the workshops period. Regarding the MALL courses, all of them were developed during the three-month period after the

workshops. Finally, each participant developed an average of 6 MALL Resources (SD=0,96) and 1 MALL Course (SD=0,49). The fact that the calculated standard deviation is rather low means that the number of MALL resources and MALL courses developed by each participant was almost evenly distributed.

5.4.3.3 Methodology

In order to address the primary research question, as well as the additional sub-questions (presented in section 5.4.2), we adopt a similar methodology for a quantitative analysis of LOs reuse proposed by Ochoa (2008) and we adopt the three levels of reuse proposed by Koper (2003). More specifically, our methodology includes the following steps:

1. **Amount of Reuse:** (a) quantitatively analyze MALL resources reuse within different MALL courses by following the metrics for measuring LOs reuse at first, second and third level, as proposed by Koper (2003) and adapted in the context of our study (see Table 5-2) and (b) compare reuse percentages with similar studies from the literature and identify differences or similarities ***(addressing sub-question 1).***

Table 5-2: Metrics for MALL Resources Reuse

Name	Reuse Metric	% of Reuse
First Level Reuse	Number of MALL Resources used by their creators in more than one MALL Course	Number of MALL Resources used by their creators in more than one MALL Course / Number of MALL Resources in the dataset
Second Level Reuse	Number of MALL Resources used by users of the Mobile2Learn Repository in more than one MALL Course	Number of MALL Resources used by users of the Mobile2Learn Repository in more than one MALL Course / Number of MALL Resources in the dataset
Third Level Reuse	Number of MALL Resources used among users of different countries of origin in more than one MALL Course	Number of MALL Resources used among users of different countries of origin in more than one MALL Course / Number of MALL Resources in the dataset

2. **Reuse vs. Metadata Completeness**: (a) calculate the completeness of MALL resources metadata records by using the following formula:

$$Q_{Comp} = \frac{\sum_{i=1}^{N} P(i)}{N} \qquad (1)$$

where P(i) is 1 if the ith metadata field has a no-null value or 0 otherwise. N is the number of metadata fields defined in the Mobile2Learn LOM application profile used for describing the MALL resources and (b) calculate Kendall's tau correlation coefficient between MALL resources reuse (at first, second and third level) and completeness of MALL resources metadata records ***(addressing sub-question 2).***

3. **Reuse vs. Number of CEFR Educational Objectives Addressed**: Calculate Kendall's tau correlation coefficient between MALL resources reuse (at first, second and third level) and the number of different metadata values related with CEFR educational objectives added for the Classification metadata ***element (addressing sub-question 3).***

5.5 Experimental Results

5.5.1 Amount of Reuse

In order to measure the reuse at first, second and third level, we applied the reuse metrics presented in Table 5-2 to the dataset of the Mobile2Learn Repository presented in Table 5-1. The results of the reuse metrics at each level is presented in Table 5-3.

Table 5-3: Amount of Reuse

Level of Reuse	MALL Resources Reused	% of Reuse
First Level Reuse	143	19,88%
Second Level Reuse	252	35,04%
Third Level Reuse	97	13,49%

As we can notice from Table 5-3, Mobile2Learn Framework noticeably facilitates reuse at first, second and third level. More specifically, reuse at first level is 19,88% but although the amount of reuse at first level is promising there were not any previous studies, so as to compare with. Additionally, at second level, Mobile2Learn Framework goes beyond (35,04%) the general trend of 22% reuse, which has been reported from similar studies. We can also notice that second level reuse is higher than first level reuse. This means that MALL resources creators acted mainly as MALL content suppliers and they were not also involved in the process of developing MALL courses. Finally, Mobile2Learn Framework outperformed also at third level reuse (13,49%), where the reported reuse from similar studies was 7% to 12%. These results provided us with evidence that Mobile2Learn Framework could (a) support reuse for the creators of the MALL resources and (b) improve reuse among users of the Mobile2Learn Framework, as well as across country boundaries (that is, among users with different countries of origin).

5.5.2 Reuse vs. Metadata Completeness

Table 5-4 presents the calculated Kendall's tau correlation coefficient between number of times of MALL resources reuse and the completeness of their metadata records, so as to identify if a statistically significant correlation between these two variables existed. We should also mention at this point that the average number of completeness of MALL resources metadata records was 0,7387 (SD=0,1102).

Table 5-4: Correlation between Number of Times of Reuse and Metadata Records Completeness

Level	Kendall's tau (τ) coefficient	p value
1st Level Reuse	0,016	<0,01
2nd Level Reuse	0,898	<0,05
3rd Level Reuse	0,467	<0,05

As we can notice from Table 5-4, there was no correlation between the number of times of reuse at first level and the metadata completeness. This means that the

completeness of metadata records does not affect reuse when this is taking place at first level (that is by the creator). This was expected since the MALL resource creator does not need to be informed about the metadata of a MALL resource that he/she has created, so as to decide whether to reuse a MALL resource or not. On the other hand, there was a significant, positive correlation (τ=0,898, p<0,05) between the number of times of reuse at second level and the metadata completeness. As a result, we can identify that metadata completeness is an important factor that influence reuse within the Mobile2Learn Framework, when reuse is taking place among all users of the Mobile2Learn Framework (second level reuse). This provides with evidence that the LOM application profile used for characterizing the MALL resources of the Mobile2Learn repository (as presented in section 5.3.2.2) includes meaningful metadata elements, which can enhance MALL resources reuse when they have been completed by the MALL resources' creators. Finally, there was also a positive correlation (τ=0,467, p<0,05) between the number of times of reuse and the metadata completeness for third level reuse but this correlation was weaker than the calculated correlation for second level reuse. This means that reuse across country boundaries (third level) is less strongly linked with completeness of the MALL resources metadata records. This could be explained by the fact that reuse taking place across country boundaries could be linked with the completeness of only specific metadata elements of MALL resources metadata records related with the facilitation of cross-country reuse. This is further investigated and discussed in the next section.

5.5.3 Reuse vs. Number of CEFR Educational Objectives Addressed

Table 5-5: presents the calculated Kendall's tau correlation coefficient between the number of times of MALL resources reuse and the number of different metadata values related with CEFR educational objectives added for the Classification metadata element.

Table 5-5: Correlation between Number of Times of Reuse and number of CEFR Educational Objectives Addressed

Level	Kendall's tau (τ) coefficient	p value
1st Level Reuse	-0,037	<0,05
2nd Level Reuse	0,768	<0,01
3rd Level Reuse	0,945	<0,05

As we can notice from Table 5-5, there was no correlation between the number of times of reuse at first level and the number of CEFR educational objectives addressed for each MALL resource. This means that number of educational objectives addressed for each MALL resource does not affect its reuse when this is taking place at first level (that is by the creator). This was expected, since the MALL resource creator is able to reuse a MALL resource created by him/her without being informed about the educational objectives that this MALL resource is targeting. On the other hand, there was a positive correlation (τ=0,768, p<0,01) between the number of times of reuse at second level and the number of CEFR educational objectives addressed. As a result, we can identify that the number of CEFR educational objectives addressed for each MALL resource is a notable factor that influence reuse within the Mobile2Learn Framework, when reuse is taking place all users of the Mobile2Learn Framework (second level reuse). Finally, there was also a significant positive correlation (τ=0,945, p<0,05) between the number of times of reuse and the number of CEFR educational objectives addressed for third level reuse. This means that reuse across country boundaries (third level) is noticeably linked with the number of CEFR educational objectives addressed for each MALL resource. The positive correlation at second and third level reuse with the number of educational objectives addressed by the MALL resources can be explained by the fact that the educational objectives are expressed by the CEFR levels (as presented in section 5.3.2.2). CEFR levels are widely accepted across Europe for describing achievements of learners of foreign languages and they are important information to

be exploited when reuse is taking place at second and third level. This also provides us with evidence that our proposal for enhancing MALL resources metadata with language learning educational objectives related with CEFR levels (as presented in section 5.3.2.2) was a valid approach for enhancing MALL resources reuse.

5.6 Conclusions

In this chapter, we customized the hierarchical framework (presented in section 2.3) to support open access and reuse to MALL resources within the context of MALL courses design and development. In the customized framework, namely the Mobile2Learn Framework we identified the main user roles and we presented the key tools which empower them in the process of the design and development of MALL resources and courses. Moreover, within the Mobile2Learn Framework, we conducted a quantitative analysis of MALL resources reuse, so as to measure the reuse percentage of MALL resources within different MALL courses developed by Mobile2Learn Framework, as well as to identify empirical evidence about the factors that influence the reuse within this framework.

The results of this analysis provided us with indications that:

- The proposed Mobile2Learn Framework can significantly (a) facilitate reuse taking place by the creators of the MALL resources (first level) and (b) enhance reuse among all users of the Mobile2Learn Framework (second level), as well as across users of the Mobile2Learn Framework with different countries of origin (third level). The proposed Mobile2learn Framework resulted in better second and third level reuse results compared with similar studies from the literature.
- Completeness of metadata records, as well as the number of educational objectives addressed for each MALL resource does not appear to influence the first level reuse. This was expected and can be explained by the fact that MALL resource creator is able to reuse a MALL resource created by him/her without being informed about the MALL resource metadata or educational objectives that the MALL resource is targeting. On the other hand, second level reuse is influenced mainly by the completeness of metadata records and

less strongly by the number of educational objectives addressed for each MALL resource, which are derived from the CEFR levels (as described in section 5.3.2.2). This could be explained by the fact that users, who performed second level reuse, need to be informed about all metadata elements of a MALL resource before reusing it. Additionally, third level reuse is influenced significantly by the number of CEFR educational objectives addressed for each MALL re-source and less strongly by the completeness of MALL resources metadata records. This could be explained by the fact that users, who performed third level reuse, need to be informed about suitable metadata elements (that could facilitate cross-country reuse) before reusing a MALL resource. Finally, this provided us with evidence that our proposal for enhancing MALL resources metadata with language learning educational objectives related with CEFR levels was a valid approach for enhancing MALL resources reuse.

The aforementioned indications could also facilitate developers of MALL repositories during the process of developing new repositories or enhancing existing MALL repositories towards achieving higher reuse results of MALL resources. More specifically, developers of MALL repositories should consider:

- Empowering their end-users with appropriate and user-friendly metadata authoring tools, so as to motivate them to provide complete metadata descriptions that will eventually facilitate and enhance second level reuse.
- Enhancing the metadata model that is used to describe MALL resources with language learning educational objectives related to existing commonly accepted frameworks such as CEFR. This can eventually facilitate and enhance third level reuse.

6 Concluding Remarks and Future Research

In this chapter the conclusions of the research work conducted in this thesis are presented. Moreover, possible directions for future research are proposed.

6.1 Conclusions

This thesis proposed a hierarchical open access framework (including, hierarchical elements, main user roles and relationships between them) that supports the different levels of granularity in OERs (namely, educational content, learning activities, educational courses, education and/or training programs). Within the proposed framework, a set of tools, which empower the identified user roles within the various stages of a typical e-Learning chain namely, creation, publication, discovery, acquisition, access, use, reuse and delivery of OERs, were presented. The principles of modular design introduced by the proposed hierarchical framework could be potentially exploited by existing OER initiatives towards addressing the particularities of the different OERs' granularity levels, as well as for supporting reuse of OERs at these levels.

Next, the lowest hierarchical element of the proposed hierarchical framework was studied, namely the educational content in the form of LOs and the process of LOs reuse was investigated. This has been achieved by identifying the aspects of LOs reuse within the context of LAs design and development. Consequently, a detailed workflow for LOs lifecycle that can support LOs reuse was proposed and a set of metrics for cost effective LOs reuse was defined. These metrics can be used from interested parties for cost benefit analysis of the LOs reuse process within the context of existing OERs initiatives.

Additionally, the proposed hierarchical framework was customized to support two different fields of application, namely, Technology-enhanced Training of People with Disabilities and Mobile Assisted Language Learning (MALL). For both fields of application, it has been identified that LOs reuse is highly needed, so as to reduce the costs for developing new LOs. The conducted experiments for measuring LOs reuse for both cases of customizing the proposed framework provided us with evidence that:

- The customized hierarchical framework for supporting Technology-enhanced Training of People with Disabilities can support open access and re-use of LOs within the context of educational courses design and development. More specifically, 27,43% of the total LOs developed for supporting Technology-enhanced Training of people with motor disabilities were re-used within two or more educational courses developed for this disabled user group, whereas 34,23% of the total LOs developed for supporting Technology-enhanced Training of people with low vision were re-used within two or more educational courses developed for this disabled user group.
- The customized hierarchical framework for supporting MALL can support open access and re-use of LOs within the context of educational courses design and development. More specifically, 35,04% of the total LOs developed for supporting MALL were re-used within two or more MALL courses. It has been also identified that there is strong correlation between LOs reuse and completeness of LOs metadata records.

The aforementioned results could be useful for enhancing existing or developing new OERs initiatives towards achieving higher reuse results of OERs. Finally, it should be mentioned that the proposed hierarchical framework can contribute to the agenda of Opening up Education European Initiative (European Commission, 2011), where a number of related aspects of openness are emerging in different areas, such as those described below and illustrated in Figure 6.1:

- **Open Curriculum:** learners can mix educational resources, learning activities, and/or educational courses for different disciplines to meet their needs. This places learners in charge of their own learning and ensures that they will learn what they need to meet their personal desires and requirements.
- **Open Learning:** teachers, experts and/or peers can share new ideas and new understanding during the learning process. This provides learners with opportunities for self-determined and independent learning.
- **Open Assessment:** instead of formal evaluation of learning results, previously led by accredited education providers, assessment of what learners have learned can be carried out by their teachers, others and peers during the

learning process via peer to peer or crowd-sourced assessment with on-demand accreditation for learners.

- **Open Platform:** cloud–based provision and the use of open standards make it easier for different platforms and services to exchange information and data.

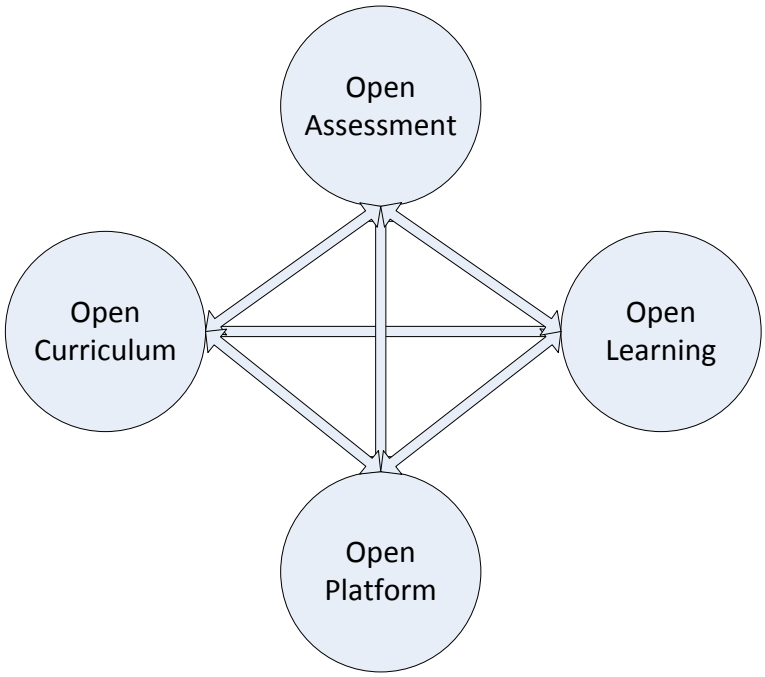


Figure 6.1: Opening Up Education - Aspects of Openness

Open education could bring new opportunities for innovation in education in different levels (school education, higher education and lifelong learning) that will not only support institutions to implement the fundamental values of institution based education but it will also shift the focus from traditional lecturing to more learner-centred learning.

6.2 Future Research

Our future research includes the extension and the adaptation of the proposed hierarchical framework and its tools in order to support the emerging trend of Massive Open Online Courses (MOOCs). MOOCs are defined as: "*online courses with the option of free and open registration, a publicly shared curriculum, and open-ended outcomes*" (McAuley et al., 2010) and they are widely discussed as potential alternatives to traditional university courses (Johnson et al., 2013).

The original aim of MOOCs was to open up education and provide free access to university level education for as many students as possible. In contrast to traditional university online courses, MOOCs have two key features (Morrison, 2013):

- **Open access**: anyone can participate in a massive open online course for free.
- **Scalability:** courses are designed to support an indefinite number of participants.

A typical MOOC consists of lectures, assignments, exams, quizzes, exercises in between lectures, as well as labs. Unlike campus based education, students are allowed to submit answers and check them multiple times. Questions can be multiple choices or a student can submit an analytical answer or even a program or an essay. Assessments are done by computer or by peers to evaluate the submissions (Piech et al., 2013). MOOCs can be divided into two main categories, as follows (Morrison, 2013):

- **cMOOCs:** The 'c' in 'cMOOC' stands for "connectivism". cMOOCs illustrate concepts and principles related to the connectivism theory of learning with networks developed informally. cMOOCs emphasize connected, collaborative learning and the courses are built around a group of like-minded 'individuals', who are relatively free from institutional constraints. cMOOCs provide a platform to explore new pedagogies beyond traditional classroom settings.
- **xMOOCs:** They are taught in a similar fashion to campus-based lecture courses, and they follow a more behaviourist approach. The 'x' in 'xMOOC' stands for "eXtended", since xMOOCs are essentially an extension of the pedagogical models practised within the institutions themselves, which are arguably dominated by instructional methods with video presentations, short quizzes and testing.

MOOCs are deployed in platforms (such as such as Coursera[9], edX[10], Udacity[11] etc.) that offer services for managing the massive amount of learners. The role of

[9] https://www.coursera.org/

[10] https://www.edx.org/

instructors in MOOCs is to design the initial contents, the assignments and the assessment activities that they later upload to these platforms. However, instructors play a secondary role during the enactment of MOOCs, compared to traditional online courses, since they cannot provide personalized support to the massive number of participants (Kop et al., 2011). As a result, MOOCs are facing important challenges such as the effective engagement of massive numbers of people, as well as the management of massive volumes of educational resources.

Within this context, the proposed hierarchical framework could be adapted to address these challenges as follows:

- Modules for capturing learners' actions within MOOCs delivered by the proposed framework could be developed and added to the proposed framework. These modules could be used for addressing research questions such as: "*what are the factors that might affect completion rate, as well as the effective engagement of students in MOOCs*". These factors could be used for enhancing the design and delivery of MOOCs.
- Tools of the proposed hierarchical framework such as ASK Learning Objects Metadata Authoring Toolkit 2.0 (as described in section 2.3.3.1) and ASK Learning Objects Social Tagging Toolkit 2.0 (as described in section 2.3.3.3) could be adapted and used for describing with metadata the massive volumes of educational resources used in MOOCs towards supporting their effective management and handling for designing new MOOCs or adapting existing ones. Moreover, these tools could be also adapted to enhance metadata descriptions of MOOCs stored in existing MOOCs Platforms towards supporting effective search and retrieval by interested learners.
- The ASK Learning Design Toolkit (ASK-LDT) of the proposed hierarchical framework (as described in section 2.3.3.4) could be adapted to support designing learner-centred online courses for the masses towards addressing the issue of learners' diversity in terms of country of origin, age, motivation

[11] https://www.udacity.com/

to participate, prior knowledge, accreditation needs and cultural background.

- The ASK Mobile Moodle (as described in section 2.3.3.7) could be adapted and used for providing access to MOOCs via mobile devices towards increasing learners' interactions (de Waard et al., 2012).

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Short CV

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Panagiotis has 12-year professional experience in the development and management of International, European and National projects. Panagiotis is the co-author of 67 scientific publications with at least 93 known citations and he has received the Best Poster Award in 11th IEEE International Conference on Advanced Learning Technologies (ICALT 2011), Athens, Georgia, USA, July 2011, the Best Paper Award in 2nd International Conference on Intelligent Networking and Collaborative Systems (INCoS 2010), Thessaloniki, Greece, November 2010, the Best Short Paper Award in 9th IEEE International Conference on Advanced Learning Technologies(ICALT 2009), Riga, Latvia, July 2009 and the Best Poster Award in 7th IEEE International Conference on Advanced Learning Technologies (ICALT 2007), Niigata, Japan, July 2007.

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