CHAPTER 4

AGENT BASED REUSABLE LEARNING OBJECTS IN e-LEARNING SYSTEM DESIGN

4.1 INTRODUCTION

Agent is an emerging new paradigm for next generation e-systems in various domains. Agent technology is identified by "MIT Technology Review" as one of the technologies that will change the world". An agent is a computer system that is capable of independent action on behalf of its user or owner through figuring out what needs to be done to satisfy design objectives, rather than constantly being told what to do (Jennings 1998). Agent-based computing is changing the way systems interact and how they are managed (Boris Sedacca 2006). Agent-based computing has already transformed processes such as automated financial markets trading, logistics, and industrial robotics. Agents are autonomous software systems that can decide for themselves what they need to do. Agents are capable of operating in dynamic and open environments and often interact with other agents - including both people and software. 'Agents are a way to manage interactions between different kinds of computational entities, and to get the right kind of behaviour out of large-scale distributed systems,'
says Michael Luck of the School of Electronics and Computer Science at the University of Southampton and executive director of the EU-funded agent link action co-ordination programme.

Current applications of these agents include Physics tutoring (Graesser et al. 1999), promotion of reflective thinking (Baylor 2001a), teaching of biology (Moreno 2001), and psychological counseling for families (Johnson 2001). Research has shown that these agent tutors are believable (Moreno 2001), improve performance by at least one standard deviation (SD) compared to human tutors two SDs (Cohen, Kulik, & Kulik 1982), and are useful to convey feedback through their facial mannerisms (Graesser, Person, & Magliano, 1995; Link et al., 2001; Person et al., 2001). Baylor (2001b) has also shown that students interacting with software agents attend to the advice, consider the advice and agent useful, and enjoy working with agents. A tutoring system for reading showed significant improvement in performance of high school students (Salomon, Globerson, & Guterman 1989). The technologies for creating an intelligent tutoring (IT) system have improved a great deal since then. ITs use a variety of approaches like adapting to learners needs, adjusting the grain size of learning units (from simple to complex), promoting transfer of skills to different
contexts, allowing students to abstract skills, modeling good problem solving approaches, providing appropriate feedback (based on students’ input/responses), and adapting to changing conditions (Andersen et al. 1995). Creating ITs usually requires the identification of learning tasks, creation of an ideal approach to learn the tasks (using task analysis, think-aloud problem solving), creation of possible tutor-student interactions (using expert tutors who are knowledgeable in the subject as well as tutoring), and programming the interactions into a computer system (Anderson et al. 1995). The computer systems that support these ITs include parsers (that process the student input), identification of the current state of the tutoring interactions, rules that govern the appropriate tutor responses, and the visible interface.

4.2 THE KEY CHALLENGES IN REUSABLE LEARNING OBJECT DESIGN

- Reusing and repurposing the learning objects in different courses -Software reuse is defined as “a process where the original structure of a learning object is populated with content from a different source and / or subject area and used to develop new learning activities” and repurposing involves “working collaboratively with the structure of an existing object, populating it
with familiar content and embedding it within self-defined learning activities” (Gunn, Woodgate and O'Grady 2005).

- **Bridging the gap between the student need and the learning content (personalizing)** – Traditionally, many corporations create courses made up of modules and lessons that are, in turn, made up of topics. Depending on the material to be covered, the audience, and the corporate learning and performance standards in place, a specific corporation may define their learning objects as having the same scope as their traditional lessons or as their traditional topics.

- **Fixing the size of a learning object** - will ensure a meaningful division of learning object. Wayne Hodgins (2000) refers to the baby bear analogy in answering this question indicating that RLOs should not be too big, not too small, nor too hot, nor too cold, etc. In the case of learning objects, we need them in ‘just the right’ size / amount, time, way (learning style), context, relevance, medium of delivery (paper, DVD, medium of delivery (paper, DVD, on-line, synchronous, on screen, etc.), location (desk, house, palm, field, etc.). The best definition of scope should be based on “the amount of information that can be digested by a learner at the time the learning is occurring” (Mills 2002). This leaves it open to corporations to set
their own standards for size and scope or perhaps even different standards for different content areas and job types.

- **Granularity** - The greater the level of granularity, (the smaller the object) the more flexibility there is for reuse. However, the more granular the learning object, the more that are required and the more difficult they will be to manage. This directly affects the cost of production and maintenance. A balance needs to be struck, depending on a Institute’s specific requirements, between “the extra precision gained from smaller granules and the extra cost...” (Schatz 2002).

**4.2.1 Need for agent based reusable learning object (ABRLO)**

Learning objects are static resources. Re-purposing of learning objects is a difficult task that is manually undertaken by content specialists, and is a bottleneck to the widespread reuse of learning objects for e-learning systems. The problem can be tackled by making learning objects smarter and more active, capable of re-purposing themselves on the e-learning systems. A more active learning object can be created by encapsulating the intelligent factor using agent technology. The goal of the design is to create a e-learning system which is a sequence of learning objects in a course or lesson that is personalized to a learner’s characteristics, behaviour, and skill level.
One way to add intelligence to learning objects is discussed by Atif Y., R. Benlamri, and J. Berri (2004) the system embeds intelligence in learning objects by adding metadata that describes the learner’s needs as well as some application code.

The agents essentially act as brokers of content, negotiating contextually sensitive interactions between the various parties in a learning situation. We believe that once agents are introduced, there will be a number of benefits including an increase in the amount of personalization available, a reduction of time spent on developing new courses, and an enrichment of the metadata that is associated with learning objects. The complex demands of the modern-day classroom require a broad range of teaching skills and management methods.

4.2.2 Encapsulation of agents with learning objects

Learning objects by themselves are effective but, in order to obtain the best results, learning objects must be used in conjunction with alternate technologies that allow for the use of multiple learning objects, to reuse them, to observe user behavior in order to select the most suitable objects for every student, to establish a way to store, arrange, classify and extract learning objects and to display them in a proper manner so the user can manipulate them. This is achieved by the
use of Agents. The active characteristics of the learning objects can all be embodied in an agent that encapsulates the learning object. In this way, the learning object can have the intelligence and portability of an agent without drastically changing the structure of its metadata or affecting its content. The reach of the learning object is increased since it could interact with other agents in remote locations, perhaps generating new instructional content. Re-purposing and reuse of the learning object is more flexible since its agent characteristics could be used to determine whether the learning object is wholly or partly applicable to a particular request. The learning object is now an entity that is aware of itself, and can respond to queries in a more meaningful manner because of its "self-aware" nature.

The idea is to combine agent technology and reusable learning object technology in an effort to create active learning objects that would allow reuse of e-learning content. The repurposing of learning objects is currently a time-consuming task. The inclusion of ‘application code’ that permits self-awareness, self-analysis and interaction can be archived by the use of software agents. Hence, the repurposing of learning objects can be realized through an Agent Based Reusable Learning Object (ABRLO). The ABRLO is a practical solution to the problem because of the compatibility between the fields
of learning and Artificial Intelligence. Encapsulating learning content with agent technology for e-learning system design is based on object oriented analysis and design. Agent technology is appropriate for creating intelligent learning objects since they can be employed to facilitate the reuse of learning content and the communication between other ABRLOs would not be limited to single method invocation as in the object-oriented paradigm for learning objects. The task of repurposing learning material can be greatly eased by ABLOs because the intelligence of a content specialist can be built into the ABLO. Furthermore, an ABLO can fragment and reassemble learning content in a principled manner.

4.3 DESIGN OF AN AGENT BASED LEARNING OBJECT

The architecture of an agent based reusable learning object is a modular one where in the practical features of the components satisfy various requirements of an intelligent learning object. These requirements include being aware of its learning material, recognising a learner’s request and being able to respond appropriately, managing and manipulating its learning material, having knowledge of the terminology used in the domain of the learning object and, being able to interact socially with other agent-based learning objects.
An ABLO fulfilling these requirements would be self-sufficient and be able to act independently without the help of human or artificial intervention when initiating tasks such as responding to learner requests or recommending its learning material. The interacting components that make up an ABLO are held together or encapsulated by an agent. This agent allows the learning material to be reused in different contexts because it is capable of interaction and negotiation with agents that submit requests from learners. (McCalla 2004) justifies this approach by stating that the best way to handle the intricacies of satisfying a learner’s request is through the interaction between learning objects (intelligent and clearly agent-based) and the learner’s personal agent. This allows agent characteristics such as self-awareness, portability, and social interactivity to become available to the learning object. An agent-based approach could also lead to negotiation for content among other intelligent learning objects.
Figure 4.1 Agent based reusable learning object architecture

The interacting components that make up an ABLO are held together or encapsulated by an agent. This agent allows the learning material to be reused in different contexts and it is capable of interaction and negotiation with agents that submit requests from learners. The Interface Agent (IA) assigns the achieved actions and information communicated by the learner, to Curriculum Agent (CA) and to Tutoring Agent(TA).
4.3.1 The curriculum agent

The curriculum agent saves the history of progress of the learner in the exercise. While analysing the profile of the learner, this agent subsequently proposes sessions of activities. It keeps track of the evolution of the interacting system with learner and the history of progress of the learner in the exercise. The CA carries out the following operations:

- To manage the model of learner throughout the training,
- To initialize the session of training by communicating the exercise to the learners according to their courses,
- To be the person in charge for the individualisation of the training,
- To carry out the update of the history of the learner model,
- To record in the base of errors the gaps met (errors made by learner) to help the tutor to be useful to direct its interventions.

4.3.2 The tutoring agent

The tutoring agent role is to ensure the follow-up of the training of each learner, to support learners in their activities, to support the human relations and the contacts between learners and to seek to
reinforce the intrinsic motivation of learner through its own implication from guide who shares the same objectives. These interventions aim at the engagement and the persistence of learner in the realization of its training. The tutoring agent explains the method of training and helps in overcoming encountered difficulties. It also helps the learner on how he can evaluate his way, his needs, his difficulties, his rhythm and his preferences.

McCalla (2004) justifies this approach by stating that the best way to handle the intricacies of satisfying a learner's request is through the interaction between learning objects (intelligent and clearly agent-based) and the learner's personal agent. This allows agent characteristics such as self-awareness, portability, and social interactivity to become available to the learning object. An agent-based approach could also lead to negotiation for content among other intelligent learning objects.

**4.3.3 The major role of tutoring agent**

One of the major problems of traditional computer based learning systems is how provide adaptive teaching, suitable to each student. This calls for more efficient mechanisms of adaptability and assistance in problem-solving processes. The system must perform the teacher's role as much as possible, building a robust student model for each user that
would enable: adapting the syllabus to each user; helping him/her to
navigate over the course activities; giving support in the task
accomplishment, and in exercises and problems to be solved; providing
help resources anytime they are needed.

When a e-Learning environment is implemented into the
classroom for providing learning object based learning, educators prefer
usage of them to increase learners’ motivation in virtual environments.
Craig, Gholsen and Driscoll (2002) stated that one of the most
important statements with using human-like agents is that they have
possibilities and features to engage for facilitating more interaction and
meaningful communication between learners and the learning
environment. The presences of human-like agents have a positive
effect on learners’ meaningful learning progression. While engaging
learners by using human-like agents, these characters not only can
create more meaningful learning experiences (Baylor 2000), but also
help them acquire positive impact-learning performance. Johnson,
Rickel and Lester (2000) suggested that human-like agents having
many characteristics are ideal to serve as tutors, coaches, or guides in e-
learning environments to provide knowledge-based facilities to the
learners.
1) The teachers have more control over the learning environment and interactions than in a classroom setting.

2) Agents are independent objects in the system, lending to more flexibility and interactivity.

3) Computer agent can never simulate a real human instructor, Agents can better operationalize the human aspect of instruction than other computer-based methods.

4) Agent-based systems provide the potential to capture a large amount of rich data, both quantitative and qualitative (while more data is not necessarily better, the possibilities to collect useful information during the instructional process is greatly enhanced).

5) Designing agent-based learning environments with multiple agents, allows for investigating the effect of multiple perspectives or multiple teachers.

The ABRLO possesses many characteristics as they were described in agent characteristics. It is autonomous, goal-oriented, flexible and self-starting (reactivity). At this moment, work is being done to extend collaborative, communicative, adaptive and personality characteristics.
4.3.4 Interface agent

The aim was to make the system suitable for different types of users with regard to local and external searches for information and data. The interface agent acts in between the system and the user. The interface agent handles all the communication with the user. This agent is like a personal assistant who is responsible for handling user needs, and for the connection of the user with the agent(s) that will help him solve his problem. It is able to reason about the user's requests and to understand what type of need he is expressing: it singles out which of the two other agents in the system is able to solve the current problem and sends to it its interpretation of the query (using KQML - the Knowledge Query and Manipulation Language). These other two agents are the internal services agent and the external retrieval agent.

The interface agent is in charge of retrieving documents on the network. It can work in two modalities: retrieval (or query) mode and surfing mode. In the first case, it searches for a specific document following a query posed by the user: this service is activated by a direct user request. In the second case, the agent navigates the network searching for documents that, in its opinion, could interest the user. The search is driven by a user's profile built and maintained by the interface agent.
Figure 4.2 The role of interface agent in ABRLO

The relationships enable answering the competency questions formulated in the previous step.

In a nutshell, the interface agent has the following crucial system tasks:

- Assisting the user in performing requests and compiling his profile.

The user does not need to be aware of what is available on the network, how this information is structured and organised, where the repositories are localised, or what retrieval services are at disposal. This is the responsibility of the interface agent;
• Deducing the user's information needs by both communicating with him and observing his "behaviour". The agent observes the user's behaviour and the current state of the world to deduce what actions are to be performed and how to modify the current user's profile.

• Translating the requests of the user and selecting the agent(s) to solve his problem(s).

• This allows the user to completely ignore the structure of the system he is interacting with. Moreover, he can also ignore how the system works. The user interacts with a personalised interface that knows how to satisfy his requests without bothering him with all sorts of details.

• Agents' tasks are to find out exactly what users are looking for, what they want, if they have any preferences with regard to the information needed. The student agents will enable a human user to

• Tutoring agent's tasks are to make an exact inventory of (the kinds of) services and information that are being queried by students, to keep track of newly added information, etc.,

• Administrator interface - here agents mediate between students, tutor and with other agents, i.e. act as intermediaries between students and tutor. The evaluation indicates that the approach is
capable of delivering different learning objects to different students according to the learning style category.

4.3.5 Metadata

Literally, "data about data," metadata includes data associated with either an information system or an information object for purposes of description, administration, legal requirements, technical functionality, usage, and preservation. The metadata that forms part of the learning object within a repository is used to:

- store keywords and descriptive words that are relevant for people using text search
- store information about the developer/publisher
- store information on the product’s IP status, and any restrictions on use
- map learning content to discipline, curriculum topics, and/or pedagogical approach

4.3.6 Learning object repositories

Learning object repositories are collections that allow digital learning objects to be found, accessed, and used by teachers and learners. Repositories hold only the metadata and the objects themselves and harvesting means collecting metadata from discreet
repositories. The students can Search-one interface to search multiple repositories.

4.3.7 Ontology

There are semantic connections between some of these relations defined by axioms: for example, IsPartOf and HasPart are mutually inverse relations. This corresponding axiom may help in searching for information. Ontology provides a common vocabulary, and an explication of what has been often left implicit (Mizoguchi 1995). e-learning and several semantic elements that formulate a value layer capable of exploiting in knowledge sources semantically. The major problem concerning this interpretation of ontology is the complexity of e-learning.

Ontologies are a means of specifying the concepts and their relationships in a particular domain of interest. Web ontology languages, like OWL, are specially designed to facilitate the sharing of knowledge between actors in a distributed environment. Ontologies can be used in e-learning as a formal means to describe the organization of universities, courses and to define services. An e-learning ontology should include descriptions of educational organizations (course providers), courses and people involved in the teaching and learning process.
The ontological knowledge base is the model core. Therefore, it contains one or more ontologies, over which the inference mechanisms will act. To carry out the search in ontological knowledge base, a search machine is needed. This machine will verify the relationships and ontological instances codified in the ontological language.

4.3.8 Inference engine

A component of our ABLO is an inference engine and a set of inference rules. The agents have direct access to the information within the inference engine. The ABLO is intelligent, can accept and respond to stimuli, and has the potential to interact with other similar entities. The interface must engage students to read and practice. Rules that are housed in the ABLO can now operate on these facts and may be used to solve problems such as locating relevant data in ontologies, or selecting and generating inferred facts. The instances, concepts and relationships expressed within the learning material are mirrored in their ontologies, that is, the syntactic and semantic information within the learning material is captured within the ontologies. The ontology-specific markup is a simple XML file that relates the concepts within the ontology to the actual manifestations within the learning resources. This could be done within the OWL ontology by outlining the instances of concepts that essentially identify resources. However, the purpose of
the markup is to allow parts of a resource (modules) to be semantically identified without having that part of the resource physically embedded within the ontology code. The markup is not crucial for the basic behaviours of an ABLO but it becomes vital for behaviours that extract pieces of a learning object.

An ABLO could have various behaviours that are swapped in and out depending on the situation, by specifying the behaviour that needs to accompany specific requests. A behaviour that is implemented is to accept requests for learning material from another agent. This behaviour initiates the loading and scanning of the ontology attached to the learning material held by the ABLO.

4.3.9 Inference rules

Inference rules specific to the behaviour are executed and the results are gathered from the inference engine. If the results are positive, then the ABLO starts a conversation with the requesting agent whereby proposals and acceptance/rejection responses are exchanged and the appropriate resources are sent by the ABLO. The behaviour is intended to go further by extracting the specific parts of the ABLO’s learning material that are relevant to the asking agent’s request, depending on the material’s markup and context. In order to deduce whether a learning object is relevant to a request and hence whether a
particular concept exists within an ontology, inference rules are required. These rules currently perform simple operations such as identifying the existence of a particular concept in an ontology, determining the types of relationships that a concept participates in, analysing the immediate neighborhood of a concept, concluding whether a concept is a subclass or superclass of another concept, and inferring whether a concept is related to another concept via a chain of concepts.

4.4 THE KEY CHARACTERISTICS OF ABRLO

- One of the benefits provided by an agent based e-learning system is it can continuously retrieve the most up-to-date educational materials available when creating customized lesson plans.

- Another advantage of an agent based e-learning system is that it can assist tutors in monitoring students progress and facilitate interactions between the instructor and learners who are struggling with a particular topic.

- They can also be used to optimally place students in groups formed to solve specific problems.

- The key to the agent approach is to incorporate reasoning and negotiation into the computational methods used to support learning objects.
• Re-use of learning objects is achieved by reasoning in context, taking into account how learning materials are actually used, and making individual differences among students a key aspect.

4. 5 GRANULARITY OF LEARNING OBJECTS

A good learning object is like a well-made brick. It has components, each providing a quality to the overall function, prepared according to defined standards so that their combination can fit an objective purpose within a defined context. If designed correctly it can be used in a related context without the need for alteration, hence the term reusable. While this ideal is important to the life and application of the RLO, the fashionable preference is that it can be repurposed or contextualised when used within diverse contexts. Learning objects (LO) are inspired by Object-Oriented principle. A self-contained piece of learning material with an associated learning objective, could be of any size and in a range of media. Learning objects are capable of re-use by being combined together with other objects for different learning purposes. Sizing is often the most difficult for learning object builders. We are most familiar with developing units and lessons. The much smaller granule (learning object) takes some thinking about content creation. Use of the granularity scale (course, unit, lesson, learning activity, learning object) helps the developer to consider the scope of
the contents to be incorporated. Developers realize that the learning object is a resource that can be grouped with other Web pages, text documents, lab activities, and classroom presentations to meet a very specific objective within a larger learning activity, lesson, or unit. Could the content be broken into smaller 'grains' and be useful as a learning activity? Faculty often observe that the learning object doesn’t contain all of the information to teach a concept or competency. A learning object is one part of the lesson that we as an instructor can create or select and combine and reconstruct as the learner requires.

![Diagram](image)

Figure 4.3 Reusable learning objects and course unit
• **Granularity** - The smallness of each component part, and the number of these incorporated into the whole, relates to what is called the granularity. Though the term is widely used in the context of RLO design and development, there appears to be no clear-cut definition for it. Collis and Strijker describe granularity as "just one of many issues related to learning objects that have different meanings and implications in different organizational contexts".

• **The role of Granularity** - has administrative implications when considering matters related to the cost of production and also the data retrieval of each part. In relation to the size of the RLO, granularity has also pedagogical implications especially if it has insufficient componentry to be considered a suitable unit of learning. The RLO should be neither too large in comparison to the size of its components nor too small to perform the pedagogical function in meeting its learning objective. Simplicity of design applies as much to the construction of a good learning object as it does to folding a well-made paper dart; size and functionality need to be optimally balanced for the learning object to be on target.
4.5.1 Fixing the size of a learning object

A LO does not have a predetermined size. Granularity of a learning object can extend from sub-topics to topics to lessons, and their associated media elements. Collections of LO topics aggregate to form lessons, modules, courses, and curriculum libraries.

![Diagram of Learning Objects]

**Figure 4.4 Granular content of learning object**

We note that learning objects at topic level can be aggregated to form e-learning lessons (instruct), and also used as topic resources for Knowledge Management reference resources (inform), and as Performance Support wizards and cue cards (guide). Figure 4.5 represents a common way of planning content organization. Topic level is a composition of digital media elements: text, graphics, animation, audio, video, and interactive user interface components.
Figure 4.5 Content organization structure

Granularity can include any size. The term learning object can be used in misleading ways. IEEE, for instance, has developed the following definition which is so broad as to include almost anything that exists: "any entity, digital or non-digital, that may be used for learning, education or training." For our purposes here, the meaningfulness of a LO is achieved only when it serves as a concrete implementation tool for instructional strategy. "Objects should be made as simple as possible but no simpler". Granularity is based on:

- RLO based on single learning objective
- too big - more than one learning objective
- too small - won’t support a learning objective
4.5.2 Taxonomy of Educational Objectives and hierarchy of learning

Hierarchy of learning, and the associated learning outcomes are presented in Table 4.1. As one student progresses from Knowledge through the other levels to Evaluation, they advance through higher levels of learning, which require more complex cognitive processes. Taxonomy of Educational Objectives (Bloom 1956), the granularity of learning objects can be fixed based on student’s degree level as shown in Figure 4.6.

![Figure 4.6 The concepts, order of thinking and prior learning](image-url)
<table>
<thead>
<tr>
<th>Degree Level</th>
<th>Typical learning outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge</td>
<td>define; describe; enumerate; examine; identify; label; list; name; quote; reproduce; select; show; state; tabulate.</td>
</tr>
<tr>
<td>Comprehension</td>
<td>contrast; convert; describe; differentiate; discuss; distinguish; estimate; extend; generalizes; give examples; interpret; paraphrase; predict; summarize.</td>
</tr>
<tr>
<td>Application</td>
<td>apply; assess; calculate; compute; construct; control; demonstrate; determine; develop; establish; examine; illustrate; modify; relate; show; solve.</td>
</tr>
<tr>
<td>Analysis</td>
<td>analyse; classify; compare; connect; divide; explain; infer; order; separate.</td>
</tr>
<tr>
<td>Synthesis</td>
<td>adapt; anticipate; compare; compose; contrast; create; design; devise; formulate; generalize; generate; integrate; model; modify; plan; reconstructs; revise; structure; synthesize; validate.</td>
</tr>
<tr>
<td>Evaluation</td>
<td>assess; compare; conclude; criticize; critique; decide; discriminate; evaluate; interpret; judge; justify; recommend; reframes; select; summarise; support; test.</td>
</tr>
</tbody>
</table>
A degree programme involves acquiring new knowledge throughout as well as applying increasingly higher order thinking skills to existing knowledge, and students arrive able to analyse, synthesise and evaluate, for example, with some concepts. In higher education learning starts on the day of entry into university. Deep learning involves relating new information to prior learning, we operate with concepts is one dimension; the complexity or difficulty of concepts is another. We may not yet have some systematic measure of the “difficulty” of concepts and “difficulty” itself is probably not a single dimension itself; there are many different aspects of a concept that can make it difficult to comprehend.

Bloom's taxonomy applies equally well to concepts addressed in primary and secondary education. Students already come to university with an enormous range of previously acquired conceptions. Some concepts are only grasped at the knowledge/comprehension stages, but some are already used at the synthesis and evaluation stages. A degree programme should build on this, acknowledging where concepts can already be used creatively, developing the use of concepts grasped at the knowledge/comprehension stages, and introducing new concepts. If we fail to recognise this prior learning, we cannot align first year study
to the abilities and expectations of the students. The result can only be a profound dislocation, involving confusion and lack of appropriate challenge.

### 4.5.3 Granularity Agent based Learning Object

The granularity of learning objects is a serious issue when designing an e-learning system. What is the degree of granularity so that the object can be reused in a variety of situations and in a meaningful context? The agents can be used to fix the size of learning objects, for example Engineering departments are strongly need to distinguish between the three main types of engineering degree programmes: B.E., M.E., and Ph.D. A set of assessment criteria for different degree programmes must involve a three-dimensional table for each assessment criteria heading, breadth, depth and the degree of autonomy demonstrated by the student. The granularity of learning objects can be fixed based on the level of degree programmes using agents. This multidimensionality can be seen based on the requirement that the M.E., must differ from the B.E., in breadth, depth and the degree of autonomy demonstrated by the student. B.E., and M.E., programmes can therefore be seen as occupying different volumes in a three-dimensional space, as shown in Figure 4.7. A B.E., programme might occupy a volume in this space that is smaller, equal, or even larger than
the M.E., but the volume occupied would be a different shape. These three dimensions are not all that there are. Depth, for example, is not really one dimension; it breaks down into the complexity of concepts and the way in which the student is able to use concepts. There are many dimensions and the different attempts to write hierarchies of assessment criteria can be seen as different lines drawn through something that is multidimensional.

Figure 4.7 A three-dimensional granularity agent based learning object
Agent granularity consists of learning content, Metadata and practice together with other information which serves two main purposes: There is also a clear benefit to be gained by teachers and students. Where content is more accurately and precisely described and classified, there will be greater satisfaction in both searching for and using the resources. The practice of packaging and publishing learning content affords the learners a degree of personalization in that they can get the right resources they need, when they need them. For teachers, the practice results in a greater ability to plan and manage their resources, provides greater flexibility and opens up the potential for reusability of learning content.

**Meta-data assessment** - Recognising the multidimensional nature of the problem may be an essential prerequisite to any chance of eventually arriving at a truly consistent way of comparing assessment criteria. The accepted definition of **meta-data** is "data about data". Compared to traditional learning, the learning scenario in e-learning is completely different. Learners have a possibility to combine learning material in courses on their own. So, the content of learning material must stand on its own. Content is useless unless it can be searched and indexed easily. This is especially true as the volume and types of learning content increase. From the student point of view, the most
important things for searching learning materials are: what is the learning material - about (content) and in which form is this topic presented (context)?. However, while learning material does not appear in isolation, another dimension (structure) is needed to encompass a set of learning materials in a learning course.

![Image of content and context diagram]

**Figure 4.8 Metadata and learning content structure**

e-Learning is often a self-paced environment. Training needs to be broken down into small bits of information that can be tailored to meet individual skills gaps and delivered as needed. These chunks of knowledge should be connected in order to create the whole course. The structure isn’t a static one, because it depends on user type, users’ knowledge level, users’ preferences and prerequisite materials. Several kinds of structuring relations between elementary learning materials may be identified. Some of them are: prev, next,
is part of, has part, references, is referenced by, is used on, is basis for, requires, is required by.

A learning object is a digital learning resource that can be reused for different levels of students and for different courses. Since, learning objects are essentially static resources, reuse of learning objects is a difficult task that should be done by the faculty manually for different levels of (undergraduate and postgraduate) students. This problem can be solved by making learning objects smarter, more active and capable of reusing. This can be achieved by using agents. The Granularity agent presents a personalized model that responds to requests from students in an intelligent manner, allowing more sophisticated kinds of learning object reuse than what is currently available. The Proposed an Agent model for personalizing the learning content and fixing the granularity of learning objects for different levels of students like B.Sc., B.E., and M.E., based on three-dimensional aspects of breadth, depth and the degree of autonomy according to the course levels of students.

4.6 SUMMARY

The fourth chapter discusses agent-based learning objects for e-learning system design in detail. A learning object is a digital learning resource that can be reused for different levels of students and for
different courses. Since learning objects are essentially static resources, reuse of learning objects is a difficult task that should be done by the faculty manually for different levels of (undergraduate and post graduate) students. This problem can be solved by making learning objects smarter, more active and capable of reusing. This can be achieved by using agents. The agent based learning objects present a personalized model that responds to requests from other agents in an intelligent manner, allowing more sophisticated kinds of learning object reuse than what is currently available. We Propose an agent based reusable learning object model for personalizing the learning content and fixing the granularity of learning objects for different levels of students like B.Sc., B.E., and M.E., based on three dimensional aspects of breadth, depth and the degree of autonomy. Depth, for example, is not really one dimension; it breaks down into the complexity of concepts and the way in which the student is able to use concepts. This chapter discusses about personalized e-learning model using agent based learning objects to overcome the gap between the student expectation and the learning content. e-learning system design using agent based learning object technique has been proposed to achieve the above goal.