ILO Diagram: A Conceptual Model for Curriculum Development

Preecha Tangworakitthaworn, Lester Gilbert, and Gary B. Wills

Abstract— **Achieving intended learning outcomes in education is an ongoing topic within distance learning and educational communities. In this paper, the ILO diagram – a novel conceptual model for curriculum development – is proposed to support not only instructional designers in designing and developing courses of study, but also learners and instructors in performing the courses' learning and teaching activities. The relationships and constraints of the ILO diagram are introduced and discussed, a case study of applying the ILO diagram is demonstrated, and the contributions of the ILO diagram are summarised.**

Index Terms — **Curriculum Development, Instructional Design, Educational Programs, Educational Activities, Intended Learning Outcome, ILO.**

I. Introduction

RECENTLY, the design of learner-centric educational activities is usually based upon constructivism, the theory that knowledge is actively constructed by learners based on their experiences [4], [15]. In contrast, the instructivist approach is instructor-focused, starting from the instructor's understanding of the subject matter to be taught [24]. Instructivism remains the major method of teaching in institutions, such as schools, colleges, and universities, where learners receive information conveyed to them. Absorption and accumulation, otherwise identified as the sponge method of teaching [23] and the banking approach of learning [8], are the techniques used by learners to deal with curriculum content [16].

We argue that constructivism and instructivism are complementary. We integrate these two theories via a matching strategy, using the intended learning outcome (ILO) to support learning and teaching. The term ILO has been introduced to indicate what the learners will be able to do by the end of a lesson, course, or programme [5], [12].

Practically, designing an ILO structure, in which the subject matters and their relationships are integrated with the capabilities to be learned, is a challenge for the instructional designer. In this paper, a novel methodology of ILO structural design is proposed to support not only instructional designers in their systematic design and development of courses of study, but also instructors and learners in undertaking their teaching and learning activities.

The following sections discuss five aspects of the research reported in this paper. First, the theoretical background of ILOs is presented through Bloom's taxonomy of educational objectives and Merrill's component display theory. Second, the constructivism and instructivism matching model (CIMM) is introduced. Third, the concepts of the ILO model are introduced. Fourth, the ILO diagram is applied to a case study. Finally, the contributions of the ILO diagram are discussed.

II. Theoretical Background

Theoretically, the taxonomy of educational objectives has been used to classify the goals of educational system. It is used as guidance for knowledge creators (i.e., instructors, educators, researchers, or instructional designers) who deal with curricular questions and clarify educational problems with better refinements [2]. Furthermore, specifically, it assists instructional designers to elucidate objectives so that it becomes easier to design the learning activities and prepare the supporting materials [25].

Many approaches refer to the taxonomy of educational objectives as the theoretical basis for defining educational plans. For instance, instructional designers construct a course curriculum as a range of achievable learning outcomes [14], or researchers develop specific educational taxonomies, e.g. for computer science education [9]. In this paper, two principal theories widely used in the design of courses are discussed, namely, Bloom's taxonomy of the cognitive domain, and Merrill's component display theory.

A. *Bloom's Taxonomy of the Cognitive Domain*

In 1956, Bloom and his colleagues published their taxonomy of the cognitive domain covering the cognitive skills used in learning activities [2]. It comprises six categories:

"1. Knowledge refers to the ability to recall, remember, and recognise relevant knowledge from long-term memory.

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2. *Comprehension refers to the ability to understand and construct the explanation (and meaning) of things.*
3. *Application refers to the ability to apply and accomplish the process (or procedure) through the executing and implementing.*
4. *Analysis refers to the ability to analyse and decompose data and information into its components through the classifying, differentiating, and experimenting.*
5. *Synthesis refers to the ability to aggregate elements together to initiate the functional whole through categorising, generalising and organising.*
6. *Evaluation refers to the ability to evaluate and criticise based on a given purpose."* [2].

Bloom's taxonomy is widely used in the construction of learning outcomes. Although taxonomies have been developed to cover the affective and psychomotor domains of learning, educators use the cognitive domain to define their desired outcomes. While Anderson and Krathwohl [1] have proposed an updated version, this research has adopted Bloom's original taxonomy as the fundamental part of the proposed CIMM model and conceptual model of ILOs.

B. Merrill's Component Display Theory

Merrill extended the work of Gagné [10] through the development of component display theory called CDT [21]. Originally, Gagné proposed that different types of learning outcome (classified on a performance dimension) require different types of learning condition [10], [11]. Based on this assumption, Merrill broadened the classification scheme by adding a content dimension, producing CDT [19]. Consequently, CDT is grounded by a two-dimensional classification scheme comprising performance and content [21].

The performance dimension covers three categories, namely, find, use, and remember. This dimension represents the learner's capabilities with respect to particular subject matter content, and is a condensed version of Bloom's cognitive taxonomy. The content dimension (also called subject matter) involves four types, namely, fact, concept, process, and principle.

CDT can be used to design and develop learning and teaching activities [21]. This research has adopted CDT in its definition of ILO components.

III. Proposed Approach

We aim to reconcile constructivism and instructivism in developing an equivalent architecture to support learning and teaching by illustrating through the constructivism and instructivism matching model called CIMM [27], depicted in Fig. 1.

The model classifies pedagogical content into four layers, namely, goal, knowledge, activity and ILO. The two pedagogical approaches of constructivism and instructivism are shown in CIMM as two different layered perspectives. The constructivist perspective comprises learning goals which lead to the consideration of learner's knowledge, conceived as prior knowledge and new knowledge. Learning the new knowledge involves learning activities, which are included in ILOs. On the other hand, the instructivist perspective comprises teaching goals which lead to the consideration of the instructor's knowledge, and then to appropriate teaching activities which are incorporated into ILOs. The connection between these two otherwise separate perspectives is at the ILO layer, hence the model's name is "matching model". This leads to the analysis of the ILO in following section.

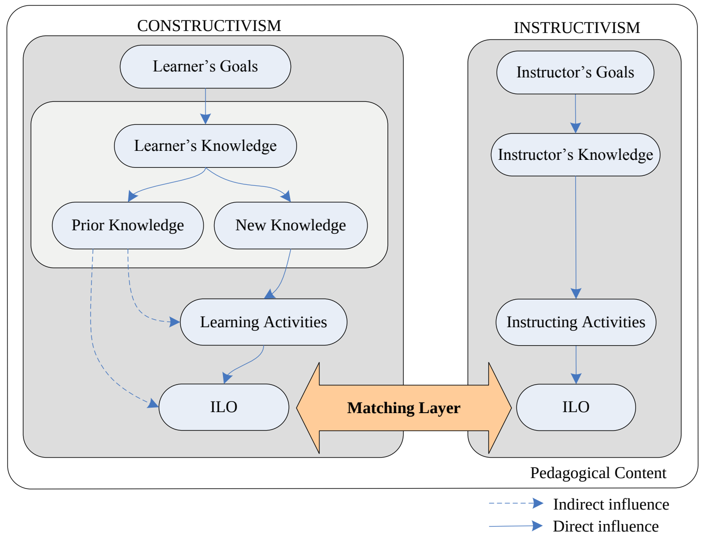


Fig. 1. The Constructivism and Instructivism Matching Model (CIMM)

IV. The ILO Model

This section presents a conceptual model of the ILO showing its structure and representation.

A. Matching Learner and Instructor ILO

The instructor and the learner share the pedagogical content of the instructor's goals and the learner's goals, instructor's knowledge and learner's knowledge, and the instructing activities and learning activities. Fig. 2 illustrates the matching of the ILOs.

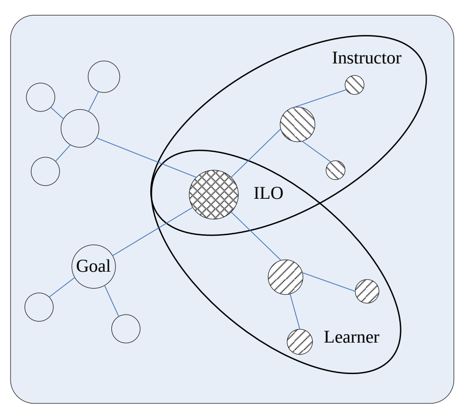
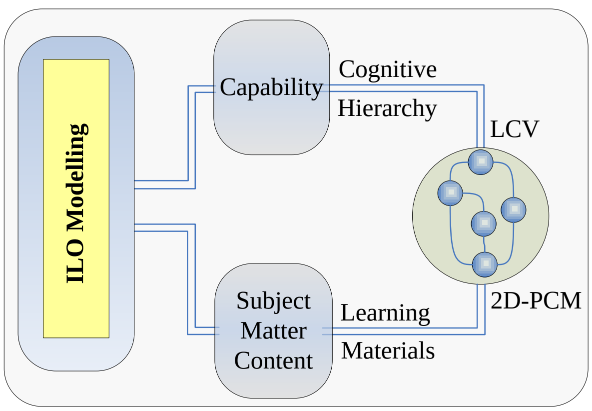


Fig. 2. Matching of Learner and Instructor ILOs

Besides the instructor's and learner's views, there is a matching perspective that normally occurs during the course of study. This is because the teacher and the learner share similar goals of the pedagogical activities: teaching and learning activities. It is their joint intention to gain an understanding of the subject matter content (or learning material) which is the ideal of the pedagogical activities. Hence, the shared goals are determined to be the indication leading to the improvement of the learned capabilities.

B. *ILO Components*

The structure of the ILO introduced in this research is based on the competence structure proposed by Sitthisak and Gilbert [26], where an ILO comprises a capability and associated subject matter content. An ILO is expressed by the standard phrase: "By the end of the course, the learner will be able to..." X and Y, where X is capability and Y is subject matter content [12]. Consequently, an ILO is a planned learning outcome which expresses the learner's ability to be able to perform learning activities by the end of the course modules [17].



2D-PCM: 2 Dimensions Performance-Content Matrix
LCV: Learned Capability Verb

Fig. 3. ILO modelling

Fig. 3 illustrates the ILO modelling contributed in this research. In order to model the ILO, the component display theory [21] has been adapted to identify the ILO structure which consists of two components: capability and subject matter content. The details of two main components of ILO are discussed as follows:

1) *Capability*

Capability refers to the action or activity of the learner in performing some task, and we use Bloom's taxonomy of cognitive skills in expressing the capability component of an ILO. For instance, an ILO may state, "by the end of the course a learner will be able to design a data flow diagram"; the capability of this example is "design". A number of different verbs can express a given level of capability within Bloom's taxonomy, and in this research we refer to the particular verb used in an ILO as the learned capability verb called *LCV* (see Table 1). In this research, Bloom's taxonomy of the cognitive domain (which comprises six categories) forms the basis of a cognitive hierarchy, representing the cumulative and usually progressive accomplishments of learning. Each level of the cognitive hierarchy relies upon the learner's performance at the lower levels [7]. For example, a learner wanting to apply knowledge (application level), usually needs to both remember fundamental information (knowledge level) and understand this information (comprehension level).

TABLE 1
THE EXAMPLE OF LCV FOR EACH LEVEL OF COGNITIVE HIERARCHY [2]

Cognitive Hierarchy	LCV
Evaluation	appraise, argue, assess, contrast, criticise, evaluate, judge, justify, measure, resolve
Synthesis	assemble, categorise, create, design, establish, formulate, generalise, integrate, organise
Analysis	analyse, break down, categorise, classify, compare, differentiate, distinguish, examine, test
Application	apply, assess, change, construct, demonstrate, develop, experiment, operate, use
Comprehension	associate, change, clarify, describe, explain, express, identify, indicate, report
Knowledge	collect, define, describe, enumerate, label, list, name, order, present, recognise, state

TABLE 2
TEN RELATIONSHIPS OF 2D-PCM [21] AND ITS EXAMPLES

2D-PCM	Examples
Remember-Fact	1. Identify the value of π(Pi). 2. Name the prime minister of England.
Remember-Concept	1. Clarify the colours of rainbow. 2. Define the characteristics of gravity.
Remember-Procedure	1. State the steps in making cookies. 2. Rehearse the methods of pay online.
Remember-Principle	1. Explain the cause and effect of the Euro Collapses.
Use-Concept	1. Classify the features of hand-written styles.
Use-Procedure	1. Demonstrate how to draw ER diagram. 2. Demonstrate how to solve equation by using the Laplace transform.
Use-Principle	1. If there is a road accident in the morning, predict the possible reasons of traffic jam.
Find-Concept	1. Explore picture of Isle of Wight posted on the web. 2. Categorise learners into group of five; determine that all learners in each group share the same hobby.
Find-Procedure	1. Devise an online auction algorithm in ASP.Net.
Find-Principle	1. Discover the result of testing the chemical reaction of burning a candle if the oxygen is limited.

2) *Subject Matter Content*

Based on the component display theory proposed by Merrill [21], we define four categories of subject matter content called *SMC*, namely, fact, concept, procedure, and principle. Fact is two associated parts of information, such as, a specific name and a date, an event and the particular name of a place, etc. Concept is a concrete or abstract item with certain characteristics, such as, a human being is a primate with a bipedal gait, etc. A procedure (or process) is a set of steps for accomplishing some objective, such as, a computer program, a recipe for cooking Thai food, etc. Finally, a principle is a cause-and-effect relationship which predicts outcomes, such as, road accidents occur because of slippery roads, apples fall because of gravity, etc.

Following Merrill [21], we define a two-dimensional performance/content matrix called *2D-PCM* using Merrill's classification scheme [21], [22]. The first dimension is performance, which comprises three types: find, use and, remember. The second dimension is the subject matter content which, as before, comprises fact, concept, procedure, and principle. There are ten relationships instantiated in 2D-PCM, as shown in Table 2 with examples. Any ILO can be assigned to one of the 2D-PCM relationships.

C. *Mapping ILOs into a Diagram*

In general, a diagram is the representation of nodes (boxes) and relationships (links). In this research, a diagram is used to visualise the logical structure of ILOs and its relationships which is named as *ILO diagram*. The nodes called *ILO nodes* represent the specific ILOs of the course, whilst the links called *ILO relationships* signify the direction of the next node and its characteristics.

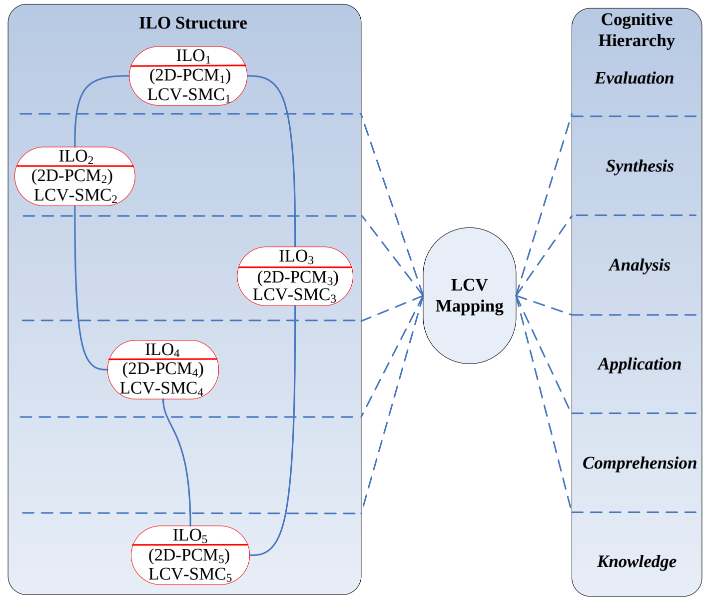
The entire set of ILO nodes and relationships form the logical structure of ILOs named as *ILO structure* (see Fig. 4) which is identified the sequences and prerequisites of learning objectives.

Structurally, each ILO node in an ILO diagram consists of four elements, namely, ILO number, 2D-PCM, LCV, and SMC. The ILO number identifies the node in the diagram. The 2D-PCM represents the classification of the node within the performance/content matrix. The SMC represents the subject matter content of the ILO, and is used to show relationships between ILOs with matching or similar SMC. The LCV of each node is used in two ways. First, it is mapped to the cognitive hierarchy as illustrated in Fig. 4. Second, more significantly, enabling ILOs are related to higher-level ILOs through consideration of the LCV.

In principle, the ILO diagram can be firstly designed by augmenting the ILO structure with the cognitive hierarchy based on Bloom's taxonomy, but later on the design and development of the ILO diagram can be applied to other taxonomies, such as, Gagné's hierarchy of learned capabilities [10], [11], or Merrill's level of performance [21].

D. *Relationship Design*

In this research, a relationship of one ILO to another represents either a partial or a whole part that shares some elements (i.e., LCV, SMC, or both LCV and SMC) in common. It is important to note that two elements of the ILO node which are LCV and SMC play important roles in relationship design, because these two elements are the representative units of the basic component of the ILO. Thus, there are two types of ILO relationship, namely, partial, and whole part. The partial part represents the fundamental structure of the basic component that holds either LCV or SMC; hence this relationship is named



2D-PCM: 2 Dimensions Performance-Content Matrix
LCV: Learned Capability Verb
SMC: Subject Matter Content

Fig. 4. The LCV Mapping Scheme

TABLE 3
THREE PRINCIPAL RELATIONSHIPS OF THE ILO DIAGRAM

Type	Notation	Description
Capability Relationship	LCV ◀ eLCV	when LCV relates to enabling LCV
Topic Relationship	SMC — SMC	when SMC relates to SMC
Inheritance Relationship	SMC ▷ sSMC	when SMC relates to superclass SMC

as the *principal relationship*. Whilst, the whole part is determined by both LCV and SMC elements, so the name of the relationship is *composite relationship*. The following sections discuss these two relationships in detail.

1) *Principal Relationships*

The three principal relationships of the ILO diagram are shown in Table 3 and discussed as follows:

- *Capability Relationship*

The value of an ILO diagram is given when ILOs which enable higher-level ILOs are identified. The result supports learning paths and learner positioning within a learning domain.

In constructing the ILO diagram, enabling ILOs are identified by their LCVs being enablers of other LCVs, hence being "eLCV"s or enabling LCVs. For example, "modify" is an enabling LCV of "create". This is because "create" is the prerequisite capability of "modify" in the intellectual skill domain. The ILO diagram notation for the capability relationship is a solid arrowhead placed near the centre of relationship line.

- *Topic Relationship*

A group of ILOs share a common topic if it has a common SMC, resulting in a topic relationship. For example, "describe DFD" shares a common SMC with "change DFD". The ILO diagram notation for the topic relationship is a simple line.

- *Inheritance Relationship*

The SMCs of two ILOs can have an inheritance relationship if one SMC refers to the superclass SMC (called *sSMC*) of the other. This relationship is based on the class hierarchy of an object-oriented UML class diagram. For instance, a data warehouse is identified as the superclass SMC of a data mart. The ILO diagram notation for the inheritance relationship is a line with the open arrowhead placed at the superclass.

2) Composite relationship

The composite relationship is determined by combining the two components of ILOs (i.e., capability, and subject matter content) which cover four elements (i.e., LCV, eLCV, SMC, and sSMC).

TABLE 4
TWO TYPES OF COMPOSITE RELATIONSHIP

Notation	Description
LCV SMC — eLCV sSMC	when capability and inheritance relationships are determined
eLCV SMC — LCV sSMC	when capability and inheritance relationships are determined

The composite relationship holds more than one principal relationship at a time. There are two types of the composite relationship represented in Table 4. In addition, the composite relationship provides the whole-part relationship of the ILO nodes. This means that a relationship occurs when LCV (or eLCV) is linked to LCV (or eLCV) and SMC (or sSMC) is related to SMC (or sSMC). For instance, a composite relationship connects "design simple ERD" with "evaluate logical model", when "evaluate" is an enabling LCV of "design" and "logical model" is a superclass SMC of "ERD".

E. Relationship Constraints

Although it can be useful to apparently design the relationship of the hierarchical structure of the ILO, the conceptual model of the ILO should contribute modelling constructs for supporting the pedagogical activities explicitly. Based on the educational purposes of the course design [12], we propose that there are three constraints of the ILO relationship which illustrate in Fig. 5.

1) No Transitive Relationship

In general, if whenever ILO_1 is related to ILO_2 and ILO_2 is related to ILO_3, then the relationship of ILO_1 is not obviously transferred to ILO_3 as illustrated in Fig. 5(a). This is because not only the capability part of the ILO cannot be conveyed, but also the subject matter content part cannot be transmitted from ILO_1 to ILO_3. For example, a learner can evaluate the ER model if he/she can previously identify the business rules and then draw the basic ER model. But he/she cannot evaluate it without drawing the ER model completely.

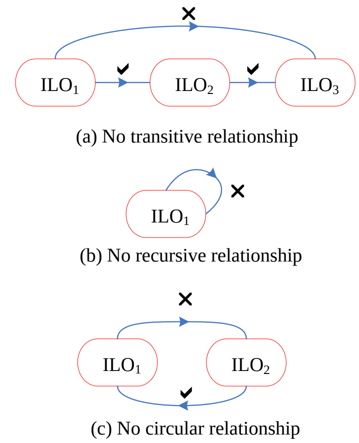


Fig. 5. Three constraints of ILO relationship

2) No Recursive Relationship

The ILO conceptual model should not include a recursive structure, when a single ILO node is related to itself as depicted in Fig. 5(b). Referring to the inheritance relationship of the ILO, each ILO node instantiates from the competency class. This means that when ILO has been referred to the instance level of the class it cannot hold the recursive relationship.

3) No circular Relationship

The principle of educational objective abstractly reveals that if ILO_1 is a prerequisite of ILO_2, then ILO_2 cannot be the prerequisite of ILO_1 simultaneously. This leads to prevent the recursive relationship of the ILO diagram.

These three relationship constraints indicate that the ILO diagram is a directed acyclic graph (DAG) for three reasons: i) it provides the relationships without loops or directed cycles, ii) there is no root node, and iii) all nodes can connect to each other.

V. A CASE STUDY OF APPLYING THE ILO DIAGRAM

In order to demonstrate how to apply the conceptual model of ILOs (ILO diagram) in designing the course of study, we consider the available published course document of IT curriculum proposed by ACM Special Interest Group on IT Education that conforms to the emerging accreditation standards for IT program [6]. In this study, the chosen course is Information Management (IM4) Data Modelling unit which consists of 11 core learning outcomes and 12 elective learning outcomes. We consider all learning outcomes and form 23 intended learning outcomes to be represented as 23 ILO nodes. We analyse and assign the suitable level of cognitive hierarchy by referring to the LCV mapping mechanism as well as the ILO relationships have been assigned to each pair of the ILO nodes. Then we can obtain the ILO diagram as in Fig. 6.

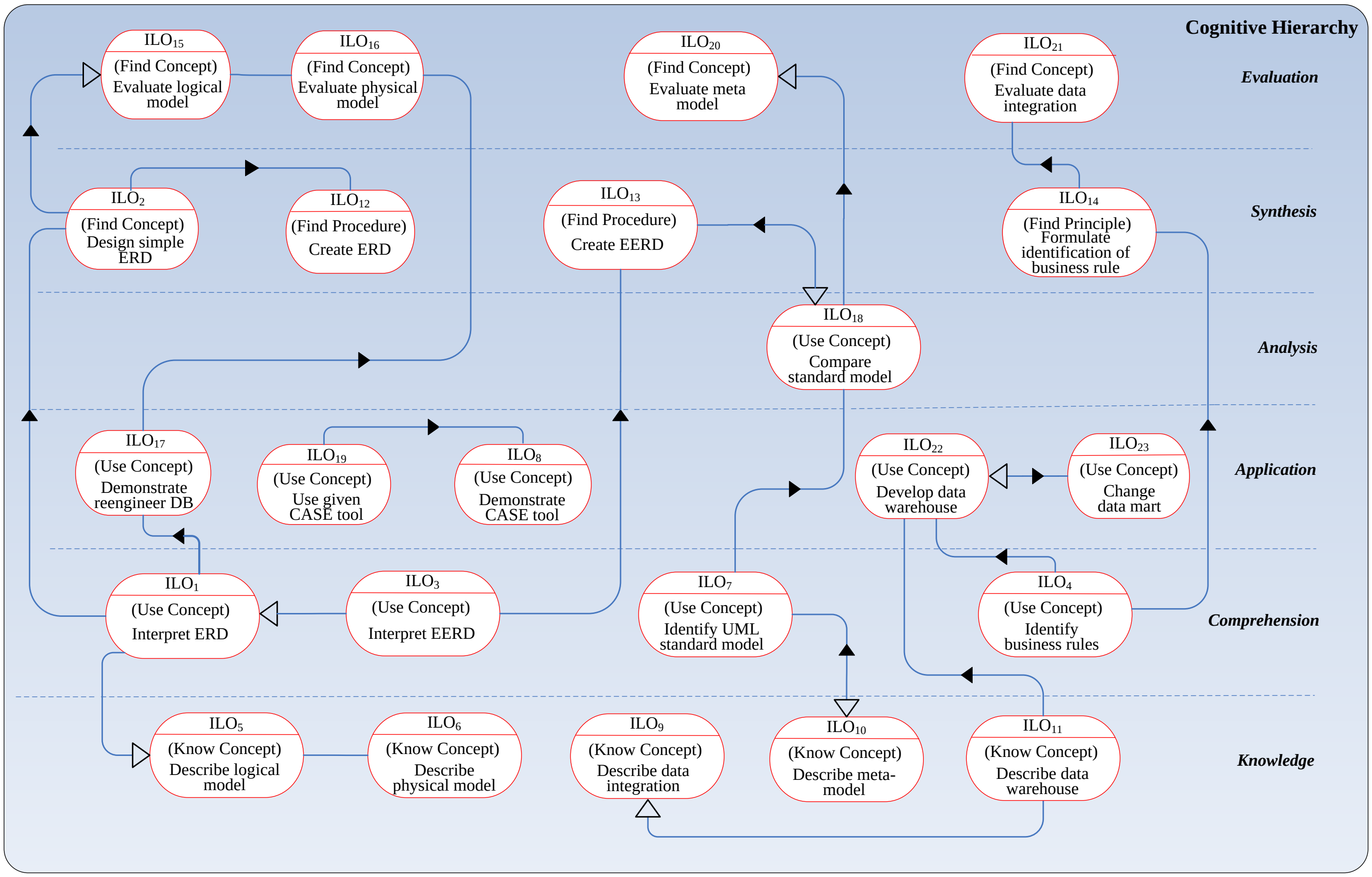


Fig. 6. The ILO Diagram of the IM4 Data Modelling Course

A case study demonstrated in Fig. 6 represents that the proposed ILO diagram has been introduced to conceptualise the course structure of the data modelling unit in the IT curriculum completely.

VI. The ILO Diagram Contributions

The proposed ILO diagram (see Fig. 6) is a novel conceptual model for the development of courses that facilitates instructional design by allowing course designers to express the logical structure of ILOs, as well as supporting both learners and instructors in performing the learning and teaching activities. The outstanding feature of the ILO diagram is that the value of the diagram is given when ILOs which enable higher level ILOs are identified, called "*enabling ILOs*". ILOs have been organised into six levels of cognitive hierarchy. The ILO diagram breaks down the learners' learned capabilities into enabling ILOs through the LCV mapping scheme (see Fig. 4). Furthermore, the enabling ILOs represent the prerequisite skills involved before the mastery of subject matters (or performance) can be achieved. Hence, both subject matters and learned capabilities are modeled and formulated explicitly in the logical structure of the ILO.

In addition, while course designers follow the ADDIE model [20] in the instructional design process [13], they can refer to the proposed ILO diagram to facilitate all processes, as summarised in Table 5.

VII. Conclusions and Discussion

The research objective has attempted to reconcile the theoretical basis of constructivism and instructivism in order to conduct an equivalent architecture for supporting learning and teaching, leading to a constructivism and instructivism matching model (CIMM) via a matching strategy through the intended learning outcomes (ILOs).

In order to pioneer courses of study which should consider all stakeholders in education, ILOs have been introduced to indicate what the learners should be able to do by the end of the course. ILOs can guide learners to perform the learning activities until they achieve their learning goals. In this paper, a novel conceptual model of the ILO structural design – the ILO diagram – was introduced to support the development of courses of study. Structurally, the ILO nodes and its elements have represented as the two-dimensional classification scheme of performance content matrix based on the component display theory. Moreover, six levels of the cognitive hierarchy adopted by Bloom's taxonomy of the cognitive domain was proposed to assign the suitable level of learned capabilities. In addition, three principal relationships, two types of the composite relationship, and three constraints were introduced. Moreover, in order to demonstrate how to apply the ILO diagram in course

TABLE 5
THE SUMMARY OF THE ILO DIAGRAM CONTRIBUTIONS FOR ALL PROCESSES OF THE ADDIE MODEL

ADDIE Process	ILO diagram contributions
Analysis	The ILO diagram facilitates the analysis of educational goals, educational strategies, learning materials, or assessment methods.
Design	• All SMC elements of ILO diagram provide learning materials, so that instructional designers can refer to it when designing the instructional products. • All LCV elements provide the learned capabilities (or action verbs), so that instructional designers can refer to it when designing the learning activities. • All ILO relationships provide the hierarchical structure of the ILOs, so that instructional designers can refer to it when designing the learning paths. • Each type of ILO relationship provides the logical link between two ILO nodes, so that instructional designers can refer to it in order to better design the example or case study. For example, the inheritance relationship is represented when Data Mart is a kind of Data Warehouse, so when Data Warehouse is taught, Data Mart should be explained as an example. • The ILO diagram represents all ILOs of the course, so that instructional designers can refer to it when designing the learning assessment (i.e., questions, tests, quiz, or other assessment methods).
Development	During the development process, using the ILO diagram as the conceptual model facilitates instructional designers in creating and initiating the courses of study.
Implementation	The ILO diagram provides the logical structure of ILOs which supports instructors and learners in executing the learning materials in the learning environment. This means that the ILO diagram can be used to assist both instructors and learners as a facilitator to envision the learning contents.
Evaluation	The ILO diagram visualises all subject matters together with the learned capabilities to support instructional designers and instructors in evaluating both formative and summative assessment processes. This means that using the ILO diagram as a facilitator to determine the mastery of subject matter according to the learned capabilities leads to having a better judgment and evaluation criteria.

development, a case study of the IM4 data modelling course was illustrated. Finally, the ILO diagram contributions were summarised and discussed.

In general discussion, this paper was scrutinised in designing the conceptual model of courses of study. Our approach concerns the direct influence of achievement goals by suggesting the learning and teaching activities through the ILO diagram. For instance, in order to change Data Mart, learner should develop Data Warehouse previously. The suggested activities can be represented as the pathfinder which can discover the direction of how learners can learn as well as how instructors can teach.

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