Evaluation of SEMANTIC:
An Intelligent English Semantic Object-Oriented Dictionary System

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Abstract━**There has been a great deal of research on natural language representation and processing, but little or no significant research on building intelligent semantic dictionary systems. This paper presents research on evaluating our intelligent English semantic dictionary system and its suitability for teaching English language to school children and for its use as a translation system, especially for non-native English speakers. SEMANTIC dictionary system is an intelligent Object-Oriented (OO) eLearning system based on advanced UML. It contains English words, their translation to Arabic, associated actions, semantic relationships, inherited actions and attributes, special and exceptional relationships and other semantics and characteristics. SEMANTIC dictionary system was tested on the 6th class of an elementary school for girls in the Kingdom of Bahrain to evaluate its effectiveness in teaching English and for its level of contribution to students learning. The analysis of experimental results are very promising.**

Keywords-eLearning; Semantic; English; Object-Oriented, Evaluation.

I. INTRODUCTION

eLearning means both teachers and students utilize electronic media (text, audio, images, animation and video), as well as education and communication technologies [3]. In recent years, the use of new teaching methods and technology in the classroom has been increasing [6]. Teachers have used the Internet for language teaching, as well as Computer-Assisted Language Learning (CALL). The use of new technologies and teaching methods, such as Internet and CALL, enhances and complements traditional language teaching. Literature on instructional technology shows that the use of the Internet in teaching has the potential to motivate students and teachers, increase their participation, and interaction in the classroom, allow for a deeper integration with the culture of the target language, and provide students with a more active role in their learning [5][6].

Nowadays, most countries, where English is not their first language, teach English language to their students [4][9]. In turn, the traditional language teaching in the classroom needs to be integrated and enhanced by applying new teaching methods [13], like eLearning [6] and information and communication technologies. As a result, it will assist English language learners to reduce mechanical memorization and develop their English language skills [10].

Some researchers applied the ideas from CAL (Computer Assisted Language) and language learning, emphasizing context for language learning, especially for abstract word learning. Some have developed a multimedia web-based CAL system which includes 13 abstract words and five main modules: Learning Material, Testing, Communication, Help, and Extensive English Learning Web Sites [14][15]. They conducted CAL in an elementary school in southern Taiwan, and they endorse that using CAL for English teaching can enhance and improve both the quality and quantity of the English language learnt. Other researchers developed computer-assisted programs for English language teaching [11]. Their researches indicated that pupils who learnt English by applying more communicative methods made greater progress in vocabulary acquisition than those who worked with the more traditional methods [7].

Electronic dictionaries contain data in digital form. Several types of dictionaries are available electronically. There are many types of dictionaries used for different purposes. Some are used for language translation [1], while others are used for science and technology like medical and engineering dictionaries. Dictionaries are developed and continuously improved to contain a number of useful and practical applications. After thoroughly searching the literature and conducting an online dictionaries survey, we could not find any similar attempts to develop an "intelligent" dictionary to be used especially as a multi-purpose multi-lingual educational tool for young students [2][8][12].

SEMANTIC dictionary system is an intelligent web-based Object-Oriented (OO) eLearning system. Each word in it belongs to a class and may have one or more subclasses. Subclasses inherit all the public attributes and relationships (operations) of their super class and this concept is utilized in all types of processing on the SEMANTIC dictionary system. For example, consider the following words or phrase "girl read cherry" unless Cherry is the name of a book and Cherry has already read it. The simple sentence that can be composed out of these words is correct grammatically, but in a real world's semantic meaning is impossible. SEMANTIC dictionary system rejects this sentence and displays the reasons which are: Girl is human, and Cherry is food and human cannot read food. Hence, SEMANTIC dictionary system creates possible class strings which is human can read information media, and selects an object randomly from this class such as Newspaper and therefore, it corrects the semantic meaning of the simple sentence and becomes: Girl

reads Newspaper. Another example: the following words are "mother feed son". SEMANTIC dictionary system accepts this simple sentence and presents the explanation which is: Mother is human, and Son is human, and human can feed human and therefore, Mother feeds Son is semantically correct. These are made possible because of the intelligent features of the OO techniques [16] and the actions (relationships) associated with each word in SEMANTIC dictionary system.

SEMANTIC dictionary system was tested on a 6th class of an elementary school for girls in the Kingdom of Bahrain to evaluate its effectiveness in teaching English, its level of contribution to students learning. The analysis of experimental results in this research shows that SEMANTIC dictionary system can help non-native young students to learn English and English semantics in a much easier manner, as well as help very young children construct simple sentences and phrases. SEMANTIC supports teachers to prepare lessons and quizzes automatically. Furthermore, it helps them to enhance the traditional methods of teaching English and thus making classrooms more interesting. SEMANTIC can also, raise students' motivation and contribution, as well as enabling students to understand the meaning of words and assists them to establish sentences correctly with semantic meaning.

Section 2 shows the Unified Modeling Language (UML) diagram for SEMANTIC ENGLISH system and how we have made enhancements and additions to UML itself. Section 3 explains how SEMANTIC dictionary helps students to learn some aspects of English language. This research presents the results of testing SEMANTIC ENGLISH system to test its effectiveness in teaching some aspects of the English language and to test its level of contribution to students' learning. The results of such testing are shown in Sections 4, 5 and 6.

II. IMPROVING UML DIAGRAM FOR THE SEMANTIC DICTIONARY SYSTEM

The Unified Modeling Language (UML) [17] is the industry-standard language for specifying, visualizing, constructing, and documenting the artifacts of software systems. It simplifies the complex process of software design, making a 'blueprint' for construction. Figure 1 shows a Diagram of our enhanced UML Diagram to demonstrate the inheritance, aggregation and relationships of the classes in SEMANTIC dictionary system. The public attributes and operations are expressed with a plus sign (+). The private attributes and operations are expressed with a minus sign (-). The exceptional operations are expressed with a less-than sign (<). The "Subject-Only" operations are expressed with an ampersand (&). The letter "b" is added to these signs (+, -, < or &) when the type of the operation is "Action By" while the letter "o" is added to them when the type of the operation is "Action On". Notice that both "Exceptional" and

"Subject-Only" operations are not a part of the original UML class diagram, but we added them, which means that their signs are according to our view, as well as the addition of the letters "b" and "o" to the signs. The signs and the letters are utilized to distinguish between the actions. In addition, Figure 1 presents the following:

- **Classes:** SEMANTIC dictionary system has several super classes and many subclasses whereas Figure 1 presents three Super classes: Human, Vegetarian Food and Information Media. In addition, it shows six subclasses, such as (Reading) of super class Information Media and (Family and People) of super class Human.
- **Instances:** In SEMANTIC dictionary system, each subclass has many instances, for example (Man, Woman, Boy and Girl) of subclass People. Another example: the subclass Fruit has many instances that are applied in SEMANTIC dictionary system while Figure 1 shows (Apple and Banana) as an example.
- **Aggregation:** A lot of aggregations are applied in SEMANTIC dictionary system, for example the super class Information Media consists of class Reading and the class Reading consists of objects or instances (Book, Magazine and Newspaper).
- **Public Operations:** SEMANTIC dictionary system has many public operations (Action By): for example; buys, sells and browses, for example: a girl buys an apple. As well as the public operations (Action On) which are generated automatically: such as; bought by, sold by and browsed by, for example: an apple is bought by a girl.
- **Private Operations:** SEMANTIC dictionary system has a private operation (Action By): "engages" for object Man. For example: a man engages a woman and a private operation (Action On): "engaged to" for object Woman. For example: a woman engaged to a man.
- **Subject_Only Operations:** SEMANTIC dictionary system contains several Subject_Only operations (Action By): such as Sits, Grows, Sleeps, Swims and Weeps. For example, a boy sits.
- **Exceptional operations:** SEMANTIC dictionary system has an exceptional operation (Action By): Cooks. For example, a boy cannot cook a cloth. Also, an exceptional operation (Action On): Cooked by. For example, a football is not cooked by a human.
- **Inheritance:** In SEMANTIC dictionary system the super classes inherit the public operations (Actions) to its subclasses. For example: the super class Human inherits its public operations such as
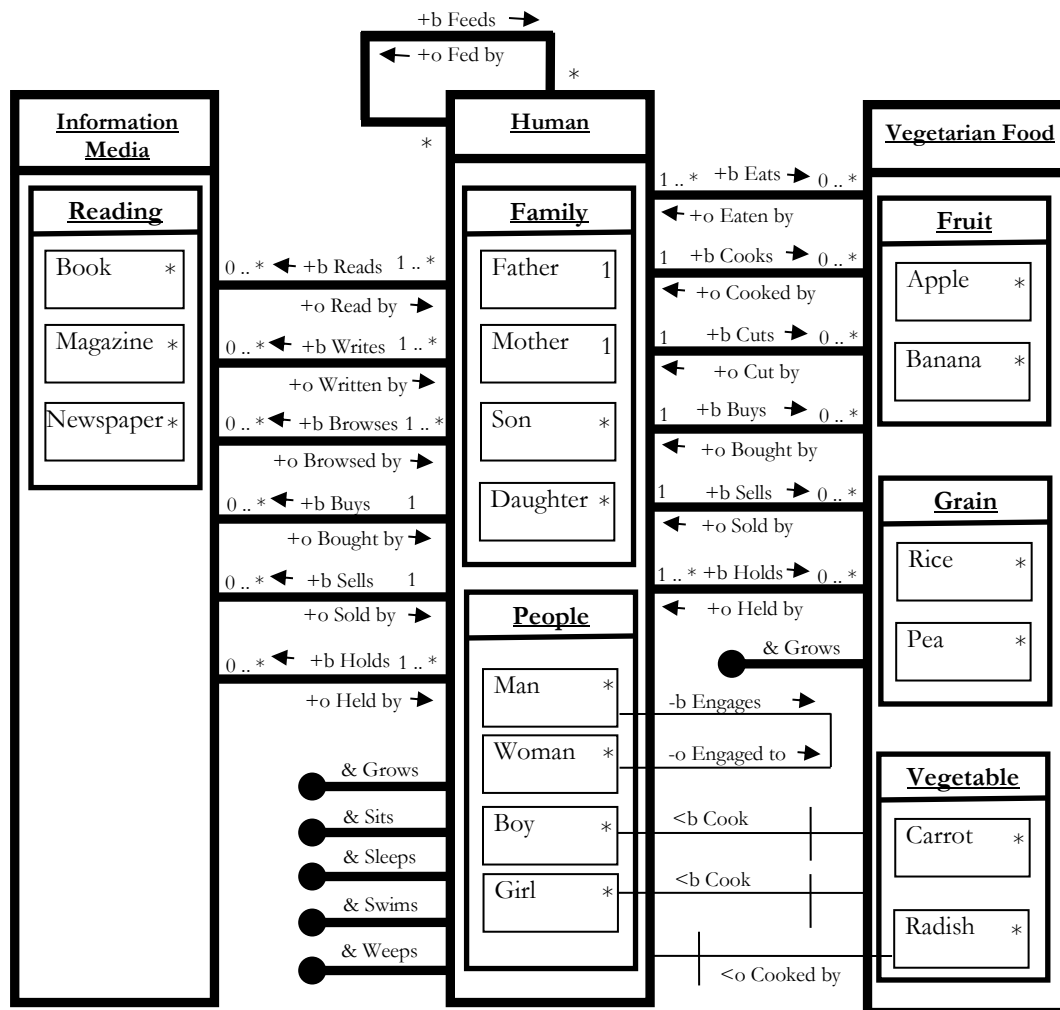
Figure 1. Example of Enhanced UML Diagram in the SEMANTIC Dictionary System.

- (eat, cook, read and write) to its subclasses (People and Family) and consequently these classes inherits these operations to its subclasses or instances like (Man, Woman, and Boy).
- **Multiplicity:** Different multiplicities are applied in SEMANTIC dictionary system. For example: "a man eats an apple", "Three men eat an apple", "a man eats two apples" and "four men eat five apples".
- **Normal Association:** SEMANTIC dictionary system has many normal associations, for example, first direction: a boy reads many (zero or many) books. Second direction: a book can be read by many (one or many) boys.
- **Recursive Association:** SEMANTIC dictionary system has a recursive association, first direction: (one or many) woman feeds (one or many) sons. Second direction: (one or many) son fed by (one or many) women.

III. SEMANTIC FOR STUDENT LEARNING

SEMANTIC dictionary helps students to learn some aspects of English language. He can learn these aspects of English language through SEMANTIC Dictionary, lessons and Checker. SEMANTIC Dictionary contains the English words (objects) and their relationships; Action By displays a list of actions that the selected word can perform and Action On displays a list of actions which can be carried out on the selected word. The classification of the word is represented by a Tree structure. For example, when the student selects a word such as '*Boy*', SEMANTIC Dictionary displays the classification of the word '*Boy*' which is *Thing > Living > Human > People > Boy*. This helps the student understand and recognize the semantic meaning of the word '*Boy*'. SEMANTIC dictionary also shows the associated diagram and images to provide further illustrations of the word to expand the student knowledge. Associated diagrams include information on the word in Arabic and English. The information can be plural of the word, gender, and description. Read is an action that Boy can achieve (Action

By), and fed is the action that can be carried out on him (Action On). When an action is selected, SEMANTIC dictionary system displays the Arabic translation, the corresponding picture and generates simple sentence using the selected word and the action. For example, '*Boy reads*' and '*Boy is fed*'. Finally the student can listen to the pronunciation of the knowledge relating to the selected word by pressing the sound image as demonstrated in Figure 2.
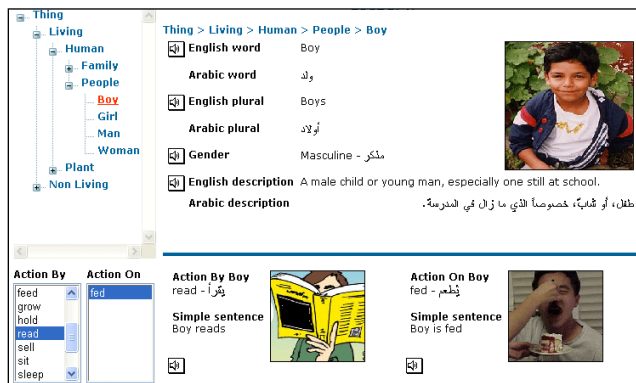

Figure 2. SEMANTIC Dictionary Tool.

SEMANTIC has three lessons; simple sentences, singular & plural nouns and the articles. SEMANTIC dictionary system explains the rules of each lesson with picture representations and examples of the words.

Lesson1 - Simple Sentences: This lesson teaches the students how to build simple sentences with grammatical correctness. Furthermore, it teaches them how to create the simple sentences with correct semantic meaning. For example, the left side of Figure 3 presents the words utilized to build a sentence of type 2; 'the subject: Man, the verb: engage and the object: Woman', it also presents the explanation for the created sentence in the right side. SEMANTIC dictionary system accepts this sentence as indicated in Figure 3 and its explanation: '*Man is human*', and '*Woman is human*', and '*human can engage human*', and this action ('*engage*') is special for the man; therefore '*Man engages Woman*'. SEMANTIC dictionary system follows the same manner with type 1, as shown in Figure 4.
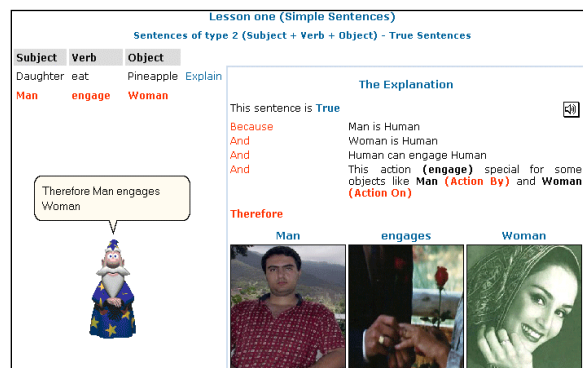

Figure 3. SEMANTIC Dictionary System accepts the created Sentence of Type 2.
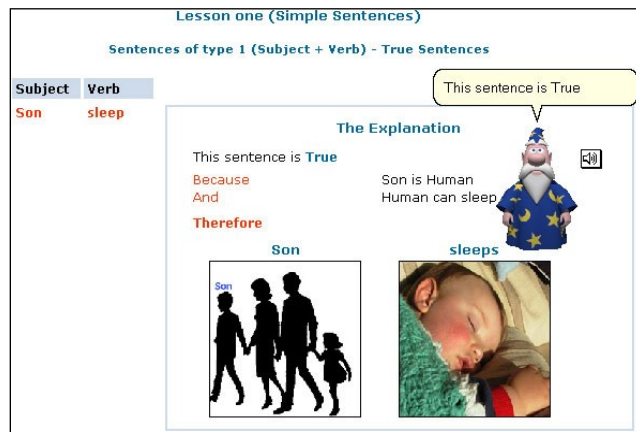

Figure 4. SEMANTIC Dictionary System accepts the created Sentence of Type 1.

Another example is that SEMANTIC dictionary system rejects the created sentence and generates possible category strings to be matched with it as illustrated in Figure 5. The words utilized to build a sentence of type 2 are: 'the subject: Woman, the verb: cook, the object: Newspaper'. SEMANTIC dictionary system rejects this sentence because: 'Woman is human', and 'Newspaper is information media' and 'human cannot cook information media', and it creates possible class string which is 'Human can cook Vegetarian Food' and selects an object randomly from this class, such as 'Potato', and therefore, it corrects the semantical meaning of the sentence and becomes: 'Woman cooks Potato'. Same approach that SEMANTIC deal with the wrong semantic meaning for sentences of type 1; see Figure 6. This lesson exposes the intelligent feature of SEMANTIC dictionary system such as accepting or rejecting the created sentences on its semantical meaning, correcting the wrong sentences and generating correct sentences randomly. In addition, it provides the explanation for accepting or rejecting any sentence.
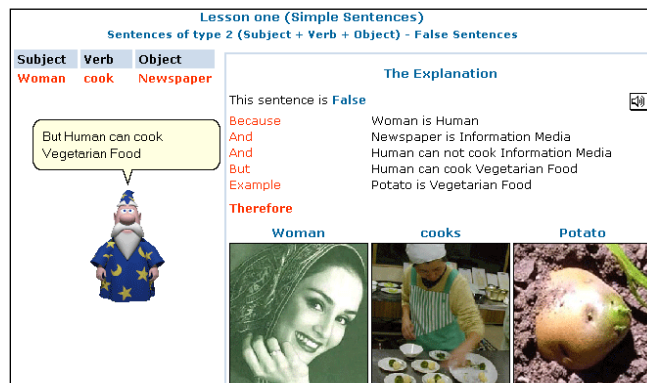

Figure 5. SEMANTIC Dictionary System rejects the created Sentence of Type 2.

Figure 6. SEMANTIC Dictionary System rejects the created Sentence of Type 1.

Lesson2 – Singular and Plural Nouns: This lesson teaches the students the comparison between singular and plural nouns in English language and presents the rules that help them to make the plural of the singular nouns. Further, SEMANTIC dictionary system generates four possible sentences from the words Subject (S), Verb (V) and Object (O) that are exposed in the left side, using singular & plural nouns rules i.e. [singular (S) singular (O), singular (S) plural (O), plural (S) singular (O) and plural (S) plural (O)].

For example: The words; Subject (S): Man, Verb (V): Cut and Object (O): Tomato. The sentences that SEMANTIC dictionary system creates are:

- Singular (Subject & Object): Man cuts Tomato
- Plural (Subject) & Singular (Object): Not proper in the real world
- Singular (Subject) & Plural (Object): Man cuts Tomatoes
- Plural (Subject & Object): Men cut Tomatoes

This example indicates that only the second sentence is not proper in the real world, which means that more than one man would not cut one tomato. Therefore, SEMANTIC dictionary system gives a message 'Not proper in the real world'. The intelligent part in this lesson is that SEMANTIC dictionary system generates sentences from three words (Subject, Verb and Object) depending on the singular and plural nouns rules as well as make sure that the generated sentence is proper in the real world. When the generated sentence is not proper in the real world, it shows this message 'Not proper in the real world'.

Lesson 3 – The Articles: this lesson teaches the students the definitions and types of the articles, as well as teaches the rules for using the articles with nouns in English.

SEMANTIC generates four possible sentences from (Subject, Verb and Object) by using the singular and plural nouns rules, and the articles rules. For example, the sentences that are created from the words (Man, cut and Eggplant), respectively; the sentences that SEMANTIC dictionary generates are:

- Singular (subject) & Singular (object)

- Indefinite (subject) & Indefinite(object): A Man cuts an Eggplant
- Definite (subject) & Definite(object):The Man cuts the Eggplant

- Plural (subject) & Plural (object)
  - Indefinite (subject) & Indefinite(object): Some Men cut some Eggplants
  - Definite (subject) & Definite(object): The Men cut the Eggplants

This lesson has some intelligence; for example, SEMANTIC dictionary system selects the appropriate article and produces sentences with grammatical correctness and semantical meaning.

Checker Tool: this tool checks the phrase semantics of simple sentences (type 1 and type 2) that entered by the student. In addition, it checks the spelling of words and when any word is misspelt, SEMANTIC will display the possible correct words for it and this will assist students to correct their sentences before checking the semantics meaning of these sentences. For example, the entered words: 'girl, read and cherry' respectively as illustrated in Figure 7. The simple sentence composed of these words is correct grammatically but in the real world meaning (semantics meaning) it is impossible. Therefore, SEMANTIC dictionary system rejects this sentence and displays the reasons which are: 'Girl is human', and 'Cherry is vegetarian food' and 'human cannot read vegetarian food'. SEMANTIC creates possible class string which is 'human can read information media', and selects an object randomly from this class such as 'Newspaper' and therefore it corrects the semantical meaning of the simple sentence and becomes: 'Girl reads Newspaper'. Moreover, it demonstrates the corresponding pictures and presents the Arabic translation.

Figure 7. SEMANTIC Rejects the Entered Sentence (General Relationship).

Another example, the entered words: 'man, feed and boy', respectively. SEMANTIC dictionary system accepts this sentence and presents the explanation, as indicated in

Figure 8: 'Man is human', and 'Boy is human', and 'Human can feed Human'. Therefore, 'Man feeds Boy'. It also demonstrates the corresponding pictures and displays the Arabic translation.

Figure 8. SEMANTIC Accepts the Entered Sentence (General Relationship).

IV. EVALUATING SEMANTICS DICTIONARY SYSTEM

This research presents the Object-Oriented technique as a new approach for the development and evaluation of an Intelligent Multi-Lingual (English - Arabic) dictionary system called SEMANTIC. SEMANTIC dictionary has a number of added features like Tree structures, words classification, simple semantic checks, pictures and voice pronunciation. The SEMANTIC dictionary was evaluated through a large scale case study conducted on elementary schools for girls in the Kingdom of Bahrain to test it for teaching some aspects of English language and to test its level of contribution to students learning. Two groups of a sixth grader (experimental and control) were selected as the subjects of the study. These students were classified into two groups: the first group (Control group) was taught the lessons only under the supervision of a teacher without using the SEMANTIC dictionary system, whereas the second group (Experimental group) was taught the lessons through the SEMANTIC dictionary system under the supervision of a teacher.

Control group: contains 16 students and those who taught SEMANTIC dictionary system tools under the supervision of a teacher without using the SEMANTIC dictionary system.

Experimental group: includes 16 students and those who were taught the same tools as the first group and under the supervision of a teacher but the SEMANTIC dictionary was used.

Sixteen hours of learning time were allotted for the experimental and control groups. The same words and teaching materials (dictionary, lessons, semantic checker, etc.,) were introduced to both groups. The couple of groups did three quizzes that generated by using SEMANTIC dictionary system. The control group answered the quizzes on paper while the experimental group answered it on the computers through the website of SEMANTIC dictionary system.

Finally, students in the experimental group and their English teacher have been asked about their opinions of the SEMANTIC dictionary system.

The achievement test includes three quizzes; quiz 1 (simple sentences), quiz 2 (singular & plural nouns) and quiz 3 (the articles).

Quiz 1 – Simple Sentences: This quiz tests the students' understanding and their ability to create simple sentences. It has two types of questions. Four grades for each question.

Quiz 2 – Singular and Plural Nouns: This quiz examines the students' understanding of singular and plural nouns as well as testing their ability to create sentences. It has two types of questions. Four grades for each question.

Quiz 3 –The Articles: This quiz examines the students' understanding of the articles and singular and plural nouns as well as examines their ability to create sentences. It has one question and eight grades for it.

V. RESULTS ANALYSIS

The results of students' achievement test of the SEMANTIC dictionary system indicated that the students in the experimental group gained higher grades in the quizzes than the students in the control group.

Figure 9 shows the average grades for the couple of questions of quiz 1 for the students in both groups (experimental and control). This figure indicates that students in the experimental group on average obtained high grades in quiz 1 (simple sentences) especially in the first question. As illustrated in Figure 9, students of the control group on average increased 0.56 on question 2, while students of the experimental group on average decreased by 0.38. However, students of the experimental group on average gained higher grades in this question than students of the control group suggesting that the SEMANTIC dictionary system could help students effectively learn English words and create simple sentences.
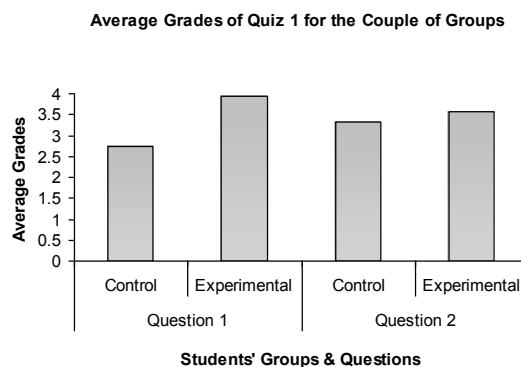

Figure 9. Average Grades of Quiz 1 (Simple Sentences).

Figure 10 exposes the average grades for the couple of questions of quiz 2 for students in both groups (experimental

and control). This figure indicates that students of the experimental group on average acquired high grades in quiz 2 (singular & plural nouns) especially in the first question. As demonstrated in Figure 10, students of the control group on average decreased by 0.06 on question 2 and students of the experimental group on average decreased by 0.69. Even so, students of the experimental group on average achieved higher grades in this question than students of the control group suggesting that the SEMANTIC dictionary system could help students effectively learn singular & plural nouns, and generate sentences that has singular & plural nouns.

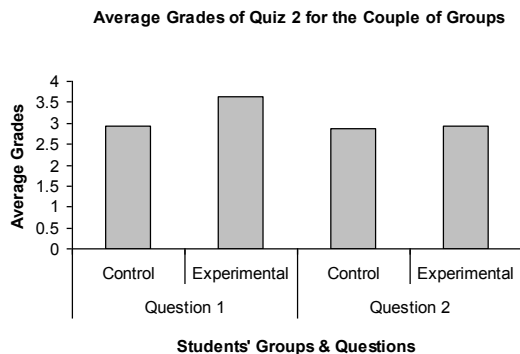**Average Grades of Quiz 2 for the Couple of Groups**

Figure 10. Average Grades of Quiz 2 (Singular & Plural Nouns).

Figure 11 presents the average grades for question 1 of quiz 3 for students in both groups (experimental and control). This figure indicates that students of the experimental group on average gained high grades in quiz 3 (the articles). In this quiz, students of the experimental group obtained on average around 5 and students of the control group on average acquired about 3. These results are low because of the time spent for teaching the two groups "The Articles" lesson score is less than other lessons suggesting that the SEMANTIC dictionary system could help students effectively learn the articles, and organize sentences that contains the articles, as well as the singular & plural nouns.
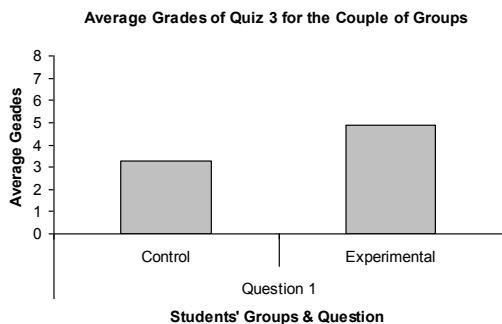
Average Grades of Quiz 3 for the Couple of Groups

Figure 11. Average Grades of Quiz 3 (The Articles).

VI. SURVEY RESULTS

The survey of students' opinions towards the SEMANTIC dictionary system deduced that students of the experimental group responded positively towards the SEMANTIC dictionary system; the majority of them enjoyed learning with this system, and would like to learn with this system again. In addition, they suggested publishing this system online because it helps them to learn and understand some aspects of English language easily and in a better way, as well as they can repeat the lessons and testing their understanding any time they want. Moreover, SEMANTIC dictionary system increases their cognitive semantic meaning of words and sentences and assists them to create correct simple sentences grammatically and realistically.

When the English teacher of students have been asked about her opinions towards the SEMANTIC dictionary system (students page), she said that "The SEMANTIC dictionary system is very useful for students especially the beginners and the young learners, because it enables them to understand the meaning of words and at the same time it helps to organize simple sentences and build them with grammatical correctness and semantical meaning. Displaying the classification of the word by Tree structure and covering the words with corresponding pictures makes the process of writing sentences and remembering the meaning easily and helpfully. Also, the pictures attract the students' attention so they go on learning without getting bored. Accordingly, SEMANTIC dictionary system raises their writing skills. Presenting an attractive story with animation and providing voice pronunciation of the words and sentences enhance the reading skills for students, as well assist their acquiring vocabulary."

The above results of achievement test and the survey support the significance and the advantage of the SEMANTIC dictionary system on learning English language. If the SEMANTIC dictionary system is used in elementary schools, both the teaching and learning quality should be improved and students should have greater enjoyment and success in language learning.

VII. CONCLUSION AND FUTURE WORK

This paper presented a new approach for the development and evaluation of an intelligent Object-Oriented dictionary system called SEMANTIC. The work in this research is the first to effectively use the OO concept and enhance UML to deal with English language semantics for simple phrases. SEMANTIC dictionary system was tested on a 6th class of an elementary school for girls in the Kingdom of Bahrain to test its effectiveness in teaching some aspects of the English language and to test its level of contribution to students learning. The analysis of experimental results is very promising.

Complex structures: sentences consisting of more than one structure or phrase or simple sentence with one verb. This will test the adaptability of sentence to handle multiple structures and how these structures can be integrated semantically, grammatically and structurally as one part with one objective. For example, now students can handle the

simple sentences *'man reads newspaper'*. However, the sentence '*A man reads the newspaper with drinking a cup of coffee in the afternoon*', consists of a number of structure with complex semantics and inter-relationships. Future work can focus on developing the approach to handle such complexities.

ACKNOWLEDGMENT

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