

Conceptualize the Domain Knowledge Space in the Light of Cognitive Skills

Fatema Nafa and Javed Khan

*Media Communications and Networking Research Laboratory
Department of Computer Sciences Kent State University, Kent, Ohio, U.S.A.*

Keywords: Learning Analytics, Higher Order Thinking Skills, Domain Knowledge and Relationships Extraction.

Abstract: In this paper, we propose an approach that can improve the quality of pedagogies based on Bloom's Taxonomy (BT) cognitive theory. Theoretically, any domain knowledge can be learned and taught at multiple cognitive domain levels. Moreover, other cognitive domain levels might be called, for learn specific domain knowledge. If we know the dependencies between the domain knowledge, many interesting pedagogical applications are possible. However, until now, the relationship levels between domain knowledge are highly sophisticated and required tedious human judgment to be deduced. BT theory has been explored in the psychological sciences paradigm, but has not been examined automatically. No comprehensive computer science map is currently available. This paper, explores how the BT- relationships between various domain knowledge is automatically extracted. A Bloom Topic Graph (BTG) that encodes concept space is extracted. BTG provides concept space connected as BT cognitive relationships. Our approach utilizes verbs to discover the BT cognitive relationships between computer sciences, domain knowledge. We evaluate the BT cognitive relationships using ground truth, and our approach achieves an accuracy of average 65-75%, which is significantly high.

1 INTRODUCTION

One of the most apparent problems that the common faculty member must focus on includes which domain concepts to teach, and how to rank each domain concept or teaching method for the level of thinking in terms of cognitive skills of those being taught (Bloom and Krathwohl, 1956). One way to express domain concepts, compatible with real thinking skills of the learner, is Bloom Taxonomy cognitive skills. Mechanisms for categorizing knowledge space into Bloom Taxonomy cognitive skills will improve the quality of curriculum structure, allowing appropriate course and teaching plan development. Bloom Taxonomy (BT), introduced in 1956 by Benjamin Bloom, is an idea of classifying the learning objectives in order to distinguish the fundamental questions within the education system (Bloom and Krathwohl, 1956). BT identifies three domains of educational activities: Cognitive domain (mental skills), Affective domain (growth in feelings or emotional areas), and Psychomotor domain (physical skills). Cognitive domain has come to our attention as it closely relates to the real understanding of thinking. The Cognitive domain is defined by Bloom into six levels: 1) knowledge, 2) comprehension, 3)

application, 4) analysis, 5) synthesis, and 6) evaluation.

In 2001, Anderson and a team of cognitive psychologists made a significant change to Bloom's Taxonomy, calling it the Revised Bloom's Taxonomy (Anderson et al. 2001). This change, in the Cognitive domain's levels, occurred by adding, ordering, combining, and change level's names, but keeping the same number of six levels. The revised Cognitive domain's levels from simplest to most complex are: 1) remembering, 2) understanding, 3) applying, 4) analyzing, 5) evaluating, and 6) creating. Despite the significant changes made by Anderson, which may work with some theoretical majors such as psychology, scientific majors such as computer science need specific Cognitive domain levels. Therefore, we introduce a new Cognitive domain named Computer-Science based Cognitive Domain (**CSCD**), by modifying Anderson's revised Cognitive domain.

Based on **CSCD**, we built a model, called Bloom Taxonomy Relational Model (**BTRM**), to facilitate the classification of computer science, domain concepts. Then, based on the BTRM model, we design and develop a technique to generate the relationships between computer sciences, domain

concepts automatically. Our technique is based on the use of Latent Semantic Analysis (LSA) theory to find verbs that use Singular Value Decomposition (SVD) (Landauer et al. 1998). A number of works have explored how a range of taxonomies can be applied in Computer Science (CS) to educate students more effectively. In particular, there are three ways in which such taxonomies have been applied to Computer Science: 1) to design the courses at various levels of granularity in time, 2) to design the teaching, learning, and assessment materials, and 3) the analysis of student responses to exercises in order to validate the effectiveness of items 1 and 2 above. In order to evaluate our model and technique, we used an electronic book titled "Introduction to Algorithm" to generate a knowledge map (a graph) which consists of algorithmic concepts as nodes, and the relationships between them as weighted directed edges. The weights on the edges are names of the relationships (BL1:1, BL2:2, BL3:3, BL4:4). To the best of our knowledge, this is the best accurate algorithmic map that reflects most algorithmic concepts and their relationships. This map can be used in Computer Science Departments by professors who teach algorithm courses to better understand a student's educational needs.

The rest of the paper is structured as follows: Section 2 provides an overview of the related work for BT. Section 3 explains the Computer-Science based Cognitive Domain (CSCD). Section 4 presents the key model used. Section 5 contains a detailed experiment that demonstrates a dramatic improvement in observed accuracy of analyzing CS domain knowledge.

2 RELATED WORK

Let us give an overview of various works that have investigated how Bloom's Taxonomy can pertain to the field of Computer Science. Specifically, such taxonomies have been used in four different ways: 1) course design, 2) teaching methodology, 3) the creation of learning and evaluative materials, and 4) student responses to learning activity (Machanick, 2000). In this section, we appraise the work of a number of research projects that applied Bloom's Taxonomy in the field of computer science by Machanick. Machanick presents the idea of ordering material according to the required cognitive skills taught within three computer science courses (Machanick, 2000). Bloom's Taxonomy was used to assign grades in an introductory programming course, based on Bloom-level mastery of tiered curricular

components rather than grading on a curve by (Lister and Leaney, 2003). In review of their work, the taxonomy for computer science was questioned (Johnson and Fuller, 2006). The problem is that exams regularly fail to test the knowledge of students for each level of mastery in Bloom's Taxonomy (Scott, 2003). Because of this, teachers cannot accurately assess the depth of mastery for individual students. A solution was to use Bloom's Taxonomy to assess the cognitive difficulty of computing courses in an IT program by formulating and calculating a Bloom Rating (Oliver et al 2004). A Bloom level was assigned to each test question according to the level of cognitive behaviour required to properly answer it. Using a Bloom Rating, based on the above work, a Bloom-based course assessment tool could be constructed and deployed in a second-level programming course (Burgess, 2005). The result is the assignment of a grade, based on objective measurements of learning outcomes. The paper describes the cognitive tasks required at each of the three grade tiers. Finally, Manaris et al. (Lister and Leaney, 2003) applied BT within CS to specify learning objectives of human-computer interaction courses. They presented a collection of courses for various target audiences, including freshman non-majors, junior/senior majors, and graduate students. For each course, they provided an outline containing learning objectives using BT, the amount of time to be spent on each topic, and related in-class activities. A closely related research was also done by Thompson et al. They focused on computer science assessment (Thompson, 2007). Their main goal was to use Bloom's Taxonomy to assist in designing introductory programming examinations. Research that is more recent was done by Starr et al., which focused on specifying assessable learning objectives in computer science (Starr et al., 2008). They believed that their idea of integrating Bloom's Taxonomy with computer science curriculum had made their faculty communicate more effectively, and the department's assessment program stronger. Other research work that was completed for specific computer science areas of education using Bloom's Taxonomy includes a test-driven automatic grading approach for programming (Hernán-Losada et al., 2008), Bloom's Taxonomy levels for three software engineer profiles (Borque et al. 2004), and Bloom's Taxonomy for system analysis workshops (Yadin, 2007).

In addition, the use of existing taxonomies is not as efficient for computer science. We address a novel aspect of the problem. From Kolb (Kolb, 2005) we know that different people can enter the learning cycle at different points. We modify revised BT to

show how BT-cognitive thinking would be more applicable for computer science than the existing generic ones.

Let us explain an overview from “Conceptual Knowledge Space,” Javed I. Khan, Yongbin Ma, Manas Hardas (Khan, Ma, and Hardas, 2010). They demonstrate how courses can be composed, based on knowledge ontology.(Hardas,2011) present a novel methodology to evaluate the bottom up technique for teaching programming concepts, based on theory of constructivism from educational psychology. Educators in teaching employed their technique; students do not employ or are not able to employ the bottom up technique of constructing concepts in learning. Most of the previous work does not focus on building automatic models to assist in analyzing domain concepts in level of cognitive skills. Our automatic model builds the domain concepts as graph and classifies cognitive skills between domain concepts. The next section will explain Computer-Science based Cognitive Domain (CSCD) by more details.

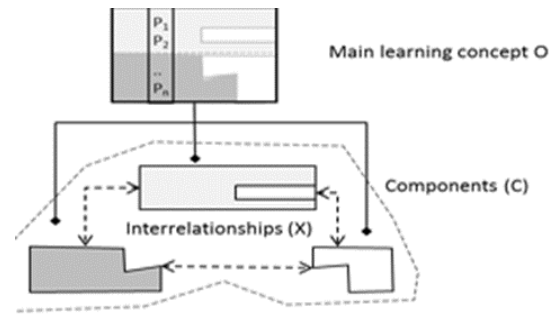


Figure 1: Parts of a learning concept.

various learning skill levels, as defined by BT. A learning concept is a unit of knowledge, which is the target of learning. It can be a topic such as “insertion sort,” “recursion”, “cache”, “disk scheduling,” etc. LeCon objects have their parts and special behaviours. A teacher would like to teach these concepts via teaching various parts of the concept. We define at least five generic parts for the LeCon object:

$$(O) = \{D, P, C, X, E\} \quad (1)$$

3 COMPUTER SCIENCE BASED COGNITIVE DOMAIN (CSCD)

Although we are using the basic Bloom Taxonomy framework (CSCD) for this paper, CSCD was introduced that provides a more flexible structure, facilitating the classification of Knowledge domain. The main goal for creating this new framework is to provide an effective ordering of BT cognitive skills for the computer sciences. CSCD introduces useful specific-hierarchy to the existing Bloom Taxonomy. BT of the cognitive skills has had a considerable impact in the last fifty years. However, this does not mean that their use is unproblematic. We create CSCD to provide a more practicable framework for assessing the domain knowledge within the CS realm. Figure 1 illustrates CSCD. CSCD represents a new understanding the at the “Understanding and Remembering” level to explain the ability to understand. The names of the levels are taken from the revised version of Bloom’s, as we feel they are sufficiently unambiguous. It is understood that the learner must traverse each level in strict sequence. It is not practical to begin the synthesis (Create) Level first, because of the degree of competency required through the Understanding and Applying Levels.

Before we proceed, it is useful to attempt to understand and define what the plausible pieces of a learning concept object (LeCon) are so that we can proceed to model the requirements for achieving

Question according to the level of cognitive behaviour required to properly answer it. Using a D: is the definition of the object O. Normally, it is a formal statement of the meaning of the pertinent concept. It is often a single sentence to a paragraph description of the salient aspects of the concept. Normally a LeCon will have a descriptive tile phrase.

The next important set of descriptions, are the various properties, features, or aspects of the concept taught. Each reinforces the understanding of the learner about the core concept. We refer to these as P= the set of properties of O. There are various ways to classify the properties of a concept. We will distinguish between functional/expressive properties as (P_f) and the other internal properties as (P_i). The functional or expressive properties of a concept are those, which are related to the use or application of the concept and must be understood by a learner to be able to apply the concept. For example, a “car” will have properties such as its maximum speed, color, weight, seating capacity, fuel consumption, brand name, etc. Depending on the goal of learning, certain types of properties are more important than others. To be able to use a car, it is important for the student to know about its functional properties, such as a car takes people from one place to another, it has seating capacity, speed etc. Certain properties such as color, brand, or type of break system may not be as important to be able to use the car. To understand a topic, often it is also important to understand its composition. C is set of sub-components of the

objects of O. Each member of C is also a learning concept in itself. Knowing an object often requires one to know what it is made of. The main object can be more than the sum or union of the sub-objects, or in other words, it is not necessary to have the equality:

$$C \geq \sum_{i=1}^n C_i \quad (2)$$

X = is the set of inter-relationships between sub components. A deeper learning not only requires one to know C, but also the relationships of Ci that resulted in the C. We also clarify that that no inheritance or preservation rule applies to LeCon objects. Property set of the parent object O can be different from the union (or some of the properties of its components). For example, none of the components of an aircraft can fly individually, but together an airplane can fly. It is also possible that properties of sub objects Ci will not be present at all in the total object O. We further identify an interesting quantity I, where I represents Innovation, which refers to the emergent properties of an object:

$$I = (P - \cup_C P_i) \quad (3)$$

Finally, to learn an object one also needs to know the context of its functional property. We denote this by E, where E is the environment in which the subcomponents of O as well as O interact. For example, for a car to transport a set of individuals from one location to another it is not enough to know that a car can transport people; you must know the destination, the route, the number of people, the capacity of the car, etc. Properties are meaningful in a context. The context is defined by another set of LeCons.

$$E = \text{Everything-O} \quad (4)$$

The above parts model now provides us the opportunity to be more specific in defining the cognitive skill levels. It is possible to organize the skill level space in multiple ways and multiple hierarchies. Below Fig3.2 is one possible arrangement.

Remembering (RM2): The minimum and lowest level of learning is RECALL. In this skill level, the learner is expected to know the definition (D) and the properties (P) of the target concepts. This is a minimum skill level. At the Recall level, understanding means that student can memorize and repeat the definition as well as properties and their values. $D+P = RM2(O)$

Knowing (KI2): In the second level of understanding (which has been stated by Bloom as the skill level UNDERSTAND or KNOW), we

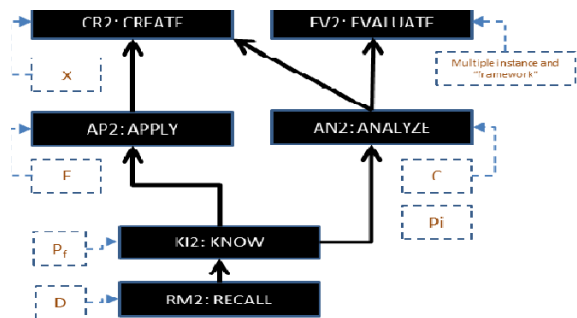


Figure 2: Learning skill levels with model Element Requirements.

require the learner to understand the meaning or semantics of the named properties besides knowing the values of the properties. For example, if a student knows that a car has rear disk brakes, then she/he has attained at least the RECALL level of understanding. However, if the student understands what rear disk brakes are, how they operate, and what the implication of having such brakes are, that will indicate the KNOW level of understanding. KI2 requires all of RM2, plus knowing the semantics. Thus, KI2 is a higher-level skill than RM2. Consequently, $D^*+P^* = KI2(O)$.

For example if we have a car as an O at the RM2 skill level, one must be able to know the name, manufacturer, model, color, shape of the car. It represents memorizing basic information about the car. One should also know the most important properties of car such as movement, engine type, and gas consumption, etc. However, at the higher KI2 level of understanding, one should also know the function of each part such as the engine, which converts the chemical energy into rotation energy to move the car; or the brake system, which slows down the car or stops it. After mastering all sub-levels of Remembering and Understanding one will be able to move to the next level of thinking, as in Figure 2. There are some cases of not master all thinking skills at the Remembering and Understanding levels, but still moving to the next thinking level with a knowledge gap.

Analysis level (AN2): The next higher level of skill is the further ability to understand the composition of a concept. This is the knowledge level at which one knows the components of O. Mental ability is to determine how the components relate to each other, what the differences are between them, as well as being able to distinguish between components. For example, one can break a car into a number of C. Chassis (C_1) which holds everything on the car, body (C_2) which has the engine, passenger compartments, the back seat, and transmission system (C_3), which is

responsible to control the speed, etc. One must be able to relate how these individual parts work together to give rise to the key functional properties of a car. To be able to attain this level he/she must master all knowledge needed in the KI2 level. $D^*+P^*+C=AN2$ (O).

Applying level (AP2): The next level of a skill applies the concept in various situations. To apply a concept one must know the functional properties of the object. However, it is not enough to know the functional properties. As a requirement, one should know the environment and real-world constraints (E). For example, to be able to apply a certain type of car to solve certain types of transportation problems, one must know the factors such as road, distance, etc. Depending on the object, O, E will normally require a specific but wider set of other concepts to be known at semantic depth. Thus, AP2 is a higher-level skill than KI2. However, one can attain AP2 level without learning the composition of O. Conversely, one might know the composition of an object without knowing how to apply it. Thus, AP2 is not necessarily a higher-level skill than AN2 or vice versa. $D^*+P^*+E^*=AP2$ (O).

Evaluating level (EV2): The next higher-level skill is the ability to evaluate an object. So, what is needed to be able to evaluate a concept? There can be at least two types of evaluations; functional and compositional. General evaluations will require all the knowledge skill of AP2 and AN2. In addition, it will require knowledge about multiple instances of the object. Additionally, it will require a judgment based on some form of measurement criteria and standards through checking and analyzing. Thus, concepts specific to the later must be known. For example, to evaluate a car, one must know about multiple instances of a car to compare their functional properties such as speed, fuel consumption, durability, etc. The learner may also be able to compare the composite objects such as engine type, break type etc. Finally, one must know associated mathematical concepts to measure those.

Creating level (CR2): One of the highest levels of skill is creating. So what is needed to create object O (the subject or creation)? For most target driven creations (regardless if it is of an engineering nature), the specific application is the motivation. Thus, it is essential for a creator to be at the AP2 level to start with. In addition, the creator must also know about the individual components (C), and how to combine them. The creator must also know about the properties of the components (C), and how the properties of these components interact among themselves (X). The creator is able to solve the puzzle

of creating the emergent property (I) from the functional properties of the components.

Creation is such a high-level skill that one more discussion is needed to illustrate the knowledge level of this skill. Once an invention is made, if a student knows D, P, C, X, E he has acquired the theoretical minimum skills needed to create. However, the first inventor normally would have to have much wider knowledge. He or she is not given the answer. The first inventor is required to experiment with a much larger set of C^* (and their properties) to invent which specific combination of C will create the target I.

4 BLOOM TAXONOMY RELATIONAL MODEL (BTRM)

In this section, we present a method to classify domain knowledge into different BT-cognitive levels. Figure 4 illustrates the overall system architecture of our BTRM model. Our model has two symmetrical parts. One part is Semantic Analysis and the other is BT-Relationship Extraction. Text in both stages goes through various steps. The objective of part one is to identify all the domain sentences within the text. The process divided into different tasks, phrases extraction, POS-tagging, stemming and stop-word filtering. Algorithm 4.1 shows the functionality of Semantic Analysis.

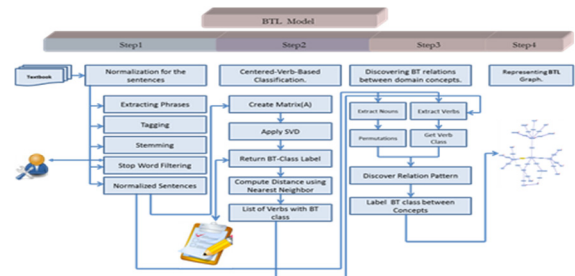


Figure 3: Overview of BTRM.

In the semantic analysis part, a pre-processing of text should be applied using Algorithm 4.1.

```

Input : ( t: text as string)
Output : A= (A: as a 3D Matrix)
Def Extraction(S: text, alpha:
    Integer, Type: string):
    For each word w in text S
        Set T=Type of w in S
        Set p=position of w in S
        Set Tag=Tagging of w in S
        For w in S:
            //Check word in the sentence
            If w [1] [0]= "V"or w[1] [0]= "N"
            Then :
    
```

```

        Count=count+1
        Check[w].Type=w[1][0]="V":
        Vlist [].append(w[0],count)
    Else:
        Nlist [].append(w[0],count)
    End If
Def Check_Pos(Vlist,Nlist,p):
    LNOUN= [], FNoun= [], VList= []
    For each Noun n in Nlist:
//Check the Leader noun and the Follower
noun for the verb in the sentence.
        If n in Nlist < p:
            LNOUN.append(n)
        Else
            FNOUN.append(n)
        End if
    End for
Return LNOUN, FNOUN
Def BuildMatrixA(LNoun, V, FNoun, W)
// based on Nouns AND Verbs
For each w in S:
A=NP.ZEROS( [len(LNoun), len(V), len(FNoun)
]))
    For i in range(len(LNoun)):
        i=LNoun.index(Pattrenlist[0])
        For j in range(len(V)):
            j=V.index(Pattrenlist[2])
            For K in range(len(FNoun)):
                K=FNoun.index(Pattrenlist[3])
            End For
        End For
    End For
    A[i][j][k]=A[i][j][k]+1
Return A

```

The algorithm4.1, shows the functions, which includes reading the texts (textbook) to separate it into sentences. In order to find out the boundaries of the sentences. We use the period (.) in order to determine the end and start point as in (Johnson and Fuller 2006). The following is an example from the textbook:

S1: {The heap sort algorithm starts by using build max heap to build a max heap on the input array.} **S2**: {The heap sort algorithm repeats that for the maxheap.}.Then, *Phrase-Extraction* applies to extract all domain-specific concepts by using N-gram algorithm (Cavnar and Trenkle) an n-gram is a sequence of n words in this paper n=1, 2, and 3 was used. We say that an N-gram occurs in a text if these domain concepts appear in the text in the same order immediately one after another.

Next, the tokenization is used to tokenize each sentence. Once the tokenization is complete, PoSTagging procedure is used as a Parsing task. We perform this in order to gain understanding of the precise meaning of the sentence, using Stanford parsing (De Marneffe et al. 2000).

Algorithm 4.1 is included three different parts: Def *Extraction*, Def *Check_Pos*, and Def *BuildMatrixA* for *Extraction* finds the type of the word in the text where Type [Leader-Noun, Verb, and Follower-Noun]. Def *Check_Pos* checks if the position of the word in the sentence verb or noun and if a noun check it if a leader-noun or Follower -noun of the verb. If so save the word and the position of the word in the text in **checklist** dictionary.

After the pre-processing step, we identify j as the index of the verb in verb list, i as the index of the leader concept and k is the index of the follower concept in the concept list. We create a three dimensional frequency matrix A [LNoun][V][FNoun] = A(i,j,k) to capture the three way associations between each leader concept, verb, follower concept triple found in the text. Each cell of the matrix A contains binary representations of the noun as follows: zero (0) represents the noun concepts that do not connect with other nouns in the sentences by verb(s), and one (1) represents the noun concepts that connected with verb. The output from semantic analysis part is used as input to the next step. The second part of our model is BT-Relationship Extraction. Before starting the extraction part some important steps is required algorithm 4.2 explains the steps.

Input: A= [LNoun] [V] [FNoun]
//from the previous step and BT= []
//Bloom Taxonomy verbs list
Output: U matrix // Dimension Reduction Matrix

```

A=NP.loadA (A= [LNoun] [V] [FNoun],
delimiter=",")
Def Calculation ( ):
    U,S, VT = SVD(A)
// where U, S, VT are a matrixes
    UR=U [: 0:3]
//The dimmintiaonl Reduction of U
    VR=VT [0:3:]
//The dimmintiaonl Reduction of VT
Def verbClassify ( ):
    L, V, F ← GetAll (SD)
//L:leader-noun,V:verb,F:follower-noun
    A [L] [F] [V] =0
    A [L] [V] [ F] ← SD
// SD: GenerateConceptLinkerCube.
    For each sd ∈ SD Do
        T<L, V, F> ← GetTuple (SD)
// Tuple data structure
        For each t in T:
            If (t not in A):
                A [t(0)] [t(1)] [t(2)]=1
            Else
                A [t (0)] [t(1)] [t(2)]++
        End For

```

```

U, D, VT ← SVD (A)
For all v ∈ V [ ] do:
    Dickknown, dickunknown ← Checkclass
    VCS, VBT)
    V-Class ← ComputeNearstNeighbor
(VCS) }
Def Checkclass (VCS, U [ ], VBT):
    Dic-VBT= { }
    //DICTIONARY TO SAVE BLOOM VERBS
    V-Dimension= [ ]
    //Verb dimension from U matrix
    Dickknown= { }
    // LIST OF VERBS FOUND IN BLOOM LIST
    Dickunknown= { }
    //LIST OF VERBS NOT FOUND IN BLOOM
    Key, value=line.Strip ().split ()
    If key in dic-VBT.keys ():
        Dic-VBT [key].append (value)
    Else:
        Dic-VBT [key] = [value]
        V= dic-VBT
        i=0
While (1):
    i=i+1
    For item in dic-VBT:
        If item in dic-VBT.keys ():
            Dickknown [item] =dic-VBT [item]
        Else:
            Dickunknown [item] = [ ]
Return Dickknown, Dickunknown
    
```

In this part, verbs are classified based on Latent Semantic Analysis (LSA). LSA is a theory and method for extracting and representing the usage meaning of domain concepts by statistical computations (Landauer et al. 1998). The process is divided into tasks; calculating SVD to divide the matrix A into three matrixes, and finding verb level in Bloom Taxonomy applying SVD to the matrix (A) will break down each dimension in the matrix using equation 5.

$$Matrix(A) = USV^T \quad (5)$$

The final sentence of a caption must end with a period.

As part of applying SVD (Landauer et al. 1998), we utilize dimensionality reduction techniques in Order to reduce the high dimensionality of Verbs matrix (U). We consider only 2-dimensions. The reason SVD is useful, is that it finds a reduced dimensional representation of our matrix that emphasizes the strongest relationships and throws away the noise. This is the key reason for using SVD to transfer our problem into a mathematical-based article.

Using *Checkclass* function we will check each verb in the verb list is in Bloom Taxonomy verbs or not. If

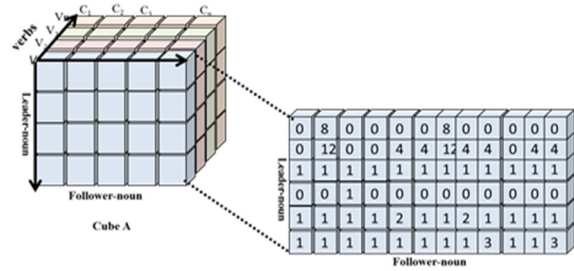


Figure 4: Matrix (A).

$$U = \begin{bmatrix} -0.45 & 0.65 & -0.56 & 0.04 & -0.19 & 0.07 \\ -0.86 & -0.16 & 0.44 & -0.01 & 0.17 & -0.03 \\ -0.10 & -0.30 & -0.37 & -0.27 & -0.04 & -0.83 \\ -0.01 & -0.05 & -0.36 & -0.16 & 0.90 & 0.17 \\ -0.12 & -0.39 & -0.24 & -0.65 & -0.32 & 0.49 \\ -0.14 & -0.54 & -0.39 & 0.69 & -0.10 & 0.18 \end{bmatrix}$$

Figure 5: Matrix (U).

$$S = \begin{bmatrix} 22.54 & 0 & 0 & 0 & 0 & 0 \\ 0 & 7.07 & 0 & 0 & 0 & 0 \\ 0 & 0 & 2.75 & 0 & 0 & 0 \\ 0 & 0 & 0 & 2.17 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0.96 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0.55 \end{bmatrix}$$

Figure 6: Matrix (S).

$$V^T = \begin{bmatrix} -0.01 & -0.64 & -0.01 & -0.18 & -0.01 & -0.10 & -0.18 & -0.17 & -0.18 & -0.02 & -0.16 & -0.18 \\ -0.18 & -0.29 & -0.18 & -0.17 & -0.02 & -0.26 & -0.11 & -0.42 & -0.86 & -0.22 & -0.12 & -0.01 \\ -0.17 & -0.01 & -0.11 & -0.23 & -0.16 & -0.30 & -0.38 & -0.21 & -0.76 & -0.33 & -0.19 & -0.07 \\ -0.01 & -0.18 & -0.01 & -0.11 & -0.04 & -0.02 & -0.01 & -0.01 & -0.01 & -0.19 & -0.22 & -0.44 \\ -0.32 & -0.17 & -0.20 & -0.21 & -0.01 & -0.21 & -0.82 & -0.02 & -0.45 & -0.14 & -0.02 & -0.01 \\ -0.31 & -0.22 & -0.18 & -0.01 & -0.17 & -0.33 & -0.21 & -0.33 & -0.01 & -0.22 & -0.01 & -0.43 \end{bmatrix}$$

Figure 7: Matrix (V).

the verb found in Bloom list will return the verb level (BL1, BL2, BL3, and BL4) as a verb class. Otherwise will return not found as in *Table 4.1*.

Next, we classify verbs using a *Nearest-Neighbour* function, by computing the distance between each two verbs after the two dimensions extracted from U matrix. Equation 6 is used to calculate Euclidean distance (d) between each two verbs.

$$Euclidean\ distance\ (d) = \sqrt{\sum_{i=1}^n (V_i + V_{i+1})} \quad (6)$$

Table 1: Shows the verb dominations extracted from SVD.

Verb	Returned-class	Dimensions from U matrix
Use	BL1	(-0.45,0.65)
Analyze	BL3	(-0.86,-0.16)
Start	BL3	(-10,-30)
Give	BL3	(-0.01,-0.05)
Build	Not found	(-0.12,-0.39)
Repeat	Not found	(-0.14,-0.54)

We need to compute distance between each two verbs dimensions were normalized by scaling it between 0 and 1 as table 2 shows that and by using Equation 7. The dimensions are scaled to fit into a specific range. There are many types of normalization; we use *Min-Max Normalization*. Min-Max Normalization transforms a value D1 and D2 which fits in the range [0, 1] as in Equation 7.

$$D_{i,0 \text{ to } 1} = \frac{D_i - D_{min}}{D_{max} - D_{min}} \quad (7)$$

Table 2: Normalized Dimensions for verbs.

Verb	Dimensions from U matrix	Normalized dimension
Use	(-0.45,0.65)	(1,0.8)
Analyze	(-0.86,-0.16)	(0.6,1)
Start	(-10,-30)	(1,0.9)
Give	(-0.01,-0.05)	(1,0.7)
Build	(-0.12,-0.39)	(0.8,1)
Repeat	(-0.14,-0.54)	(0.4,1)

Table 3: Explaining the distances between verbs.

	Use	Analyze	Start	Give
Build	0.09	0.30	0.14	0.77
Repeat	1.23	0.90	1.012	0.43

Table 3. Explaining the distances between verbs. We can see that closest distance for verb Build is Use, and closest distance for verb Repeat is Give Finally, table 4 illustrates the BT-class for each verb with the name code for the BT-class explained in section 3.

Table 4: BT-class label for verbs.

verb	Use	Analyze	Start	Give	Build	Repeat
BT-class	REM	ANE	APP	APP	REM	APP

After all verbs classified into Bloom Taxonomy we will start extracting all BT- relations in the sentences using algorithm 3.

```

Algorithm 3:
Def Distance (LNoun: list, FNoun: list,
Verb: list, alpha: integer):
    Distance=999, alpha=0.5
    If len (LNoun)>0 and len (FNoun)>0:
        For NN1 in LNoun:
            For NN2 in FNoun:
                If NN1 [0] != NN2 [0]:
                    d1=VV [1] -NN1 [1]
                    d2=VV [1] -NN2 [1]
                    D= ((d1+d2) - (2*(d1*d2)))
            End If
    End If
    
```

```

If D > Alpha
    D.remove
Else:
    Pattenlist. Append (NN1
    [0], VV [1], NN2 [0], D))
End if
Return Pattenlist
    
```

Three algorithms proposed to accomplish this are identified as *Sentence Co-occurrence of the Collocation (SCC)*, *Sentence Distance of the Collocation (SDC) Algorithm*, and *Reverb algorithm*. In addition, three of them compared with Ground Truth.

The Initial Algorithm (*SCC*) extracts all possible BT relationships from the sentences when *Alpha* >= zero. For example, in the triple ('*Heapsortalgorithm*', '*start*', '*Buildmaxheap*'), verb *start* indicates the relationship from *Heapsortalgorithm* to *Buildmaxheap*, but not in reverse. Two domain concepts, which occur together at least once in a sentence are considered as valid pairs.

The *Secondary Algorithm (SCD)*, finds all possible BT-relations, after filtering all verbs below a specific *Alpha* threshold; where *Alpha* >= 0.5. We accomplish this by measuring the distance between the verbs and all possible nouns within the sentence as in equation 8.

Finally, the *ReVerbs algorithm* takes a sentence as input, identifies relation phrases that satisfy lexical constraints, and then finds a pair of nouns from within the sentence, and uses the extracted to label each relation, without requiring any relation-specific training data (Anthony et al. 2011). Small changes modified this algorithm after the result was obtained from the ReVerbs extraction. This is accomplished by creating a two-dimension matrix just as the previous two algorithms for comparing the BT relations extraction.

5 EVALUATION AND RESULT

In order to evaluate the quality of the extracted BT-relations, we are interested in two different measures. The first one expresses the completeness of the set of extracted BT-relations, that is, how many valid BT-relations are found with respect to the total number of BT-relations, which should have been found; this is the recall rate. The second measure indicates the reliability of the set of BT-relations, that is, how many valid BT-relations are found with respect to the total number of BT-relations; this is the precision rate. These two rates were evaluated using a test sentences containing all this information.

To construct this test sentences, we have focused our attention on twenty-one sentences from introduction to algorithm book it is contains 59 important concepts from different topic from the book. In this experiment, BT-relations between concepts were 40 relations.

The concepts have been produced by our methodology. For each of these 59 concepts, and 40 relations a ground-truth extraction of valid-BT and candidate-BT-relations was carried out. PhD students had background about the topic were asked to analyze the sentences and decide what kind of BT-relations are there. Finally, out of 136 BT-relations 52 of the BT-relations examined are valid and 47 are considered as candidate-BT- relations.

The results for each noun are detailed in Table 5.1.

The following table lists the statistics from our experiments.

Table 5: Statistical of the sentences.

Algorithm	Sentences	Nouns	Verbs	BT relations
Ground Truth	21	59	27	39
SCC	21	59	27	15
SDC	21	59	27	40
Reverb	21	59	27	10

We compared the ground-truth data result with three algorithms, as Figure 8 illustrates below. It is evident from the chart that the (SDC) Algorithm is far higher than the other two Algorithms over the valid and invalid of the extraction of BT relationships.

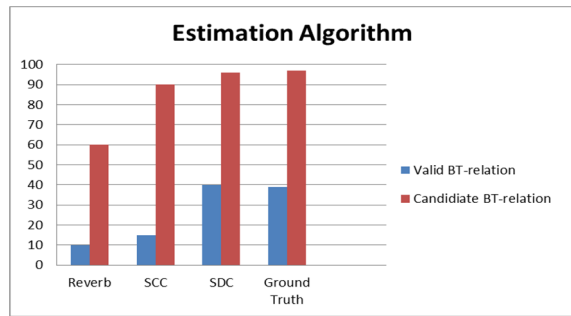


Figure 8: Comparison of BT Relationships Estimation Algorithm.

The line graph Figure 9 illustrates the behave of BT-relations and BT-candidate-relations using an Alpha (α) threshold that depends on measuring the distance between verb and two nouns connecting by the verb . Alpha (α) values is between 0-1 as the Figure shows number of BT -candidate relations goes down and number of BT -relation goes higher when (α) greater than or equal to 0.5. Overall, the BT-relations and the BT-candidate relations were far higher in the number

of extracted relations from SDC algorithm and less in the candidate relations throughout the entire Alpha threshold values.

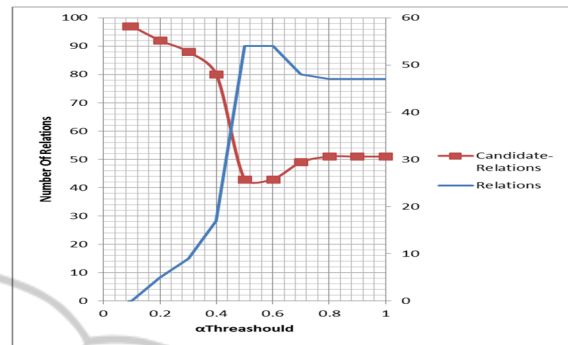


Figure 9: Alpha threshold to control the extraction for BT levels.

The line graph Figure 10 below illustrates the false positive rate for discovering BT in different BT-levels (REM, APP, ANE, EVA, and CRE) for three algorithms.

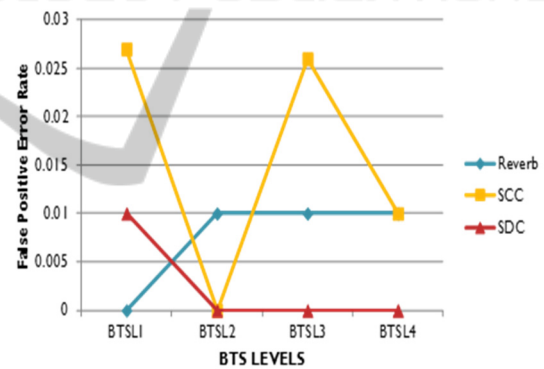


Figure 10: False Positive Error Rate of BT- Relationships Estimation Algorithm.

We conclude that the SDC algorithm using the Alpha (α) threshold is greater than or equal to 0.5. In reducing the false value, the false positive error rate changed sharply through the levels depending on the sentences that we have in each level.

6 CONCLUSIONS

This work provides various interesting aspects. First, we introduce a technique is based on theory of BT-cognitive skills from educational psychology. Concepts are taught in an order of increasing complexity so that complex concepts can be learnt with the prior levels of simpler concepts that seems to

dominate knowledge concepts. We test this technique by students where are asked to analysis some topics from introduction to algorithm book using Bloom Taxonomy levels compared with automatic technique to make operational conclusions though having many benefits, its principal weakness is that the levels do not appear to be well ordered when used to assess practical subjects. Our recommended solution is to use the new framework BT cognitive skills. This removes the strict ordering, while retaining many of the concepts of Bloom's taxonomy. This generates a way that can be used to identify a range of different learning trajectories. In addition, for discovering BT-relations, we obtain strong results on strength relations; experimental results show an accuracy of 65.5%, which is significantly high.

ACKNOWLEDGEMENTS

We take this opportunity to thank all the reviewers for this paper for the suggestions that provide helpful tips to improve the paper.

REFERENCES

- Anderson, L. W., Krathwohl, D. R., Airasian, P. W., Cruikshank, K. A., Mayer, R. E., Pintrich, P. R., ... and Wittrock, M. C. (2001). *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives*, abridged edition. White Plains, NY: Longman.
- Bloom, B. S., and Krathwohl, D. R. (1956). *Taxonomy of educational objectives: The classification of educational goals. Handbook I: Cognitive domain*.
- Bourque, P., Buglione, L., Abran, A., and April, A. (2003, September). Bloom's taxonomy levels for three software engineer profiles. In *Software Technology and Engineering Practice, 2003. Eleventh Annual International Workshop on* (pp. 123-129). IEEE.
- Burgess, G. A. (2005). Introduction to programming: blooming in America. *Journal of Computing Sciences in Colleges*, 21(1), 19-28.
- De Marneffe, M. C., MacCartney, B., and Manning, C. D. (2006, May). Generating typed dependency parses from phrase structure parses. In *Proceedings of LREC (Vol. 6, pp. 449-454)*.
- Doran, M. V., and Langan, D. D. (1995, March). A cognitive-based approach to introductory computer science courses: lesson learned. In *ACM SIGCSE Bulletin (Vol. 27, No. 1, pp. 218-222)*. ACM.
- Fader, A., Soderland, S., and Etzioni, O. (2011, July). Identifying relations for open information extraction. In *Proceedings of the Conference on Empirical Methods in Natural Language Processing* (pp. 1535-1545). Association for Computational Linguistics.
- Hernán-Losada, I., Pareja-Flores, C., and Velazquez-Iturbide, A. J. (2008, July). Testing-Based Automatic Grading: a proposal from Bloom's taxonomy. In *Advanced Learning Technologies, 2008. ICALT'08. Eighth IEEE International Conference on* (pp. 847-849). IEEE.
- Johnson, C. G., and Fuller, U. (2006, February). Is Bloom's taxonomy appropriate for computer science?. In *Proceedings of the 6th Baltic Sea conference on Computing education research: Koli Calling 2006* (pp. 120-123). ACM.
- Jurafsky, D., and Martin, J. H. (2000). *An introduction to natural language processing, computational linguistics, and speech recognition*.
- Kolb, A. Y. (2005). *The Kolb learning style inventory—version 3.1 2005 technical specifications*. Boston, MA: Hay Resource Direct, 200.
- Landauer, T. K., Foltz, P. W., and Laham, D. (1998). An introduction to latent semantic analysis. *Discourse processes*, 25(2-3), 259-284.
- Lister, R., and Leaney, J. (2003, February). Introductory programming, criterion-referencing, and bloom. In *ACM SIGCSE Bulletin (Vol. 35, No. 1, pp. 143-147)*. ACM.
- Lister, R., and Leaney, J. (2003, January). First year programming: let all the flowers bloom. In *Proceedings of the fifth Australasian conference on Computing education-Volume 20* (pp. 221-230). Australian Computer Society, Inc..
- Machanick, P. (2000, May). Experience of applying Bloom's Taxonomy in three courses. In *Proc. Southern African Computer Lecturers' Association Conference* (pp. 135-144).
- Manaris, B. and McCauley, R. Incorporating HCI into the undergraduate curriculum: Bloom's taxonomy meets the CC'01 curricular guidelines. *Frontiers in Education, 2004. FIE 34th Annual Meeting, 2004, T2H/10-T2H/15*.
- Oliver, D., Dobebe, T., Greber, M., and Roberts, T. (2004, January). This course has a Bloom Rating of 3.9. In *Proceedings of the Sixth Australasian Conference on Computing Education-Volume 30* (pp. 227-231). Australian Computer Society, Inc.
- Porter, M. F. (1980). An algorithm for suffix stripping. *Program: electronic library and information systems*, 14(3), 130-137.
- Scott, T. (2003). Bloom's taxonomy applied to testing in computer science classes. *Journal of Computing Sciences in Colleges*, 19(1), 267-274.
- Starr, C. W., Manaris, B., and Stalvey, R. H. (2008). Bloom's taxonomy revisited: specifying assessable learning objectives in computer science. *ACM SIGCSE Bulletin*, 40(1), 261-265.
- Thompson, E. (2007, January). Holistic assessment criteria: applying SOLO to programming projects. In *Proceedings of the ninth Australasian conference on Computing education-Volume 66* (pp. 155-162). Australian Computer Society, Inc..

- Yadin, A. (2007). Implementation of Bloom's Taxonomy on Systems Analysis Workshops. In Proceedings of the AIS SIG-ED IAIM 2007 Conference.
- Khan, J. I., Ma, Y., and Hardas, M. (2006, December). Course composition based on semantic topical dependency. In *Web Intelligence, 2006. WI 2006. IEEE/WIC/ACM International Conference on* (pp. 502-505). IEEE.
- Hardas, M. An Evaluation of the Constructive Teaching Methodology of Programming Concepts.

