A GAME ONTOLOGY MODEL FOR ACQURING
BUSINESS SKILLS

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Abstract— Several factors play major roles in shaping and determining the objective and effect of a game in any system of education. Unfortunately, many business games do not consider socio-cultural and environmental differences as major factors which affect the level of managerial competencies and business acumen. This work briefly discusses the factors that affect business acumen, and then presents a game ontology which serves as an advocacy framework for representing set of skills alongside the opposing factors needed to smoothly run a business in developing countries. A Game Ontology Model for Business Skills (GOMBS) was used to capture the categories of factors. Deductive model, JENA Framework and semantic web standard tool such as Resource Description Framework (RDF), Protégé, OWL-DL were used to design the framework and Dynamic Game Balancing Technique (DGBT) was used to align acquired skill set with appropriate game level experience. The outcome of this work will help game designers to come up with appropriate kind of Business Games that can help develop valuable technical, human and conceptual business skills.

Keywords— Game, GOMBS, Game Ontology, Skill Ontology, OWL-DL, Dynamic Game Balancing (DGB), Competency

I. INTRODUCTION

Appropriate kind of Business Games can help develop valuable business skills such as problem-solving, planning, investment, and business analysis, decision-making and so on. Complex puzzle games are good at developing the kind of brain functions needed to succeed in a business environment [1].

Business Games are Educational Technologies (EdTech) which extend the possibility of global economy thereby changing the way people do business and communicate. Games involve people, resources and processes. The aim is to give participants practical experiences in skills comparable to one in ‘real-life’. These EdTechs improve manager’s interpersonal skills and the dynamics of dealing with groups while avoiding racial conflicts [2]. Business games are usually competitive in character with compressed time periods, allowing the result of decisions and policies to be seen. Game designers and managers look at the world change as a challenge and an opportunity for organizational growth and individual skill development. In addition, to cope with the changes, international business educators and facilitators need to respond swiftly to the impacts of demographics, technology, and globalization in order to offer specific job skill development on global leadership, work ethic, and continuous learning [3][4].

Developing countries such as Nigeria differ from the Western world by its cultural traditions and business practices. It is therefore pertinent that virtual world of business (Games) shows the expected competence in cross-cultural awareness and practice [5][6]. Most existing games and business techniques which are developed in Western countries have not been effective tools in developing countries. Various works by Human Computer Interaction (HCI) experts recommend that correct cultural models must be represented in other to design an appropriate business games as teaching aids which must be compatible to the learning environment and cross-cultural concerns. It is therefore expedient that a single ontology approach be employed to achieve the aforementioned; hence the main objective of this work is to presents business game ontological framework for matching the various set of skills with the appropriate game environment and player experience. This work has been sectioned into nine (9) parts: Section 1 introduces Business Games and challenges facing Business Game Designers (BGD). Section 2 discusses various elements of Game Ontology Project (GOP). Section 3 discusses various categories of factors affecting skills and competencies. Section 4 discusses the usage of Ontology. Section 5 discusses the theoretical framework for Game Ontology for Business Skills. Section 6 discusses existing work. Section 7 presents the proposed Ontology and a descriptive logic of the ontology. Section 8 discusses the Dynamic Difficulty Adjustment (DDA) Techniques for acquired skills. Conclusion and recommendations were presented in section 9.

II. GAME ONTOLOGY PROJECT (GOP)

Ontology is a formal naming and definition of the types, properties, and interrelationships of the entities that exist for a particular domain of discourse. Ontologies are formal and explicit specifications of a shared conceptualization. They are mainly composed by a set of concepts or classes that characterize the formalized knowledge, a set of rules, called also properties or relations between concepts and a set of
instances or individuals belonging to the classes along with their specific properties [7][8]. Ontologies are created to limit complexity and to organize information which can then be applied to problem solving. The Game Ontology project uses concepts and methods from prototype theory as well as grounded theory to achieve a framework that is always growing and changing especially in the area of game design and game analysis.

However, beyond the GOP’s approach of developing a game ontology that identifies the important structural elements of games, the relationships and organizing them hierarchically according to content and objective, there is need to formalize the content and goal of each game that is being designed. Therefore this research work presents a framework for filtering the top-level elements of Game Ontology and to present an appropriate learning environment and content suitable for the players

The Game Ontology Elements include:

A. The Goal Level: This reflects the main objectives of a game and within the level of such game (in-game objective); it also covers the conditions that the player will meet, specifically with the progress made. There is a one-to-one correspondence between goals and entity manipulation.

B. The Entity Manipulation Level: This is the means by which players perform actions in the game in pursuit of achieving the goals set forth. This level defines how players change (temporary or permanent) the abilities and characteristics of entities in game world. [9], although the major problem in this level of ontology has remained the matching of ‘attribute verbs’ against the class of player. In a child player scenario, for example, attribute/verbs such as murder, steal, rape are considered not suitable.

C. The Rule Level: Gameplay rules are arbitrary rules that are imposed on a game world in order to transform the interactions with that world into a game playing activity. Rules that are not tightly connected to the pseudo-physical representation of a game-world are called abstract rules. Examples of these types of rules include the number of lives the player has available as well as those that determine when a game has ended [9][10][11].

D. The Interface Level: This level describes the user interface, controllers, console, control scheme and various means of presentations for the games. Presentations (such as audio or visual) can be hardware based or software based. The cultural differences must be considered to avoid scene stereotyping

III. FACTORS AFFECTING SKILLS AND COMPETENCIES

Skill is defined as ability and capacity acquired through deliberate, systematic, and sustained effort to smoothly and adaptively carry out complex activities or job functions which involves ideas (cognitive skills), things (technical skills), and or people (interpersonal skills) [12].

Competency is used as a more general description of the requirements of human beings in organizations and communities [13]. Competency is also thought of as being shown in action, in a situation and context that might be different the next time a person has to act. In emergencies, competent people may react to a situation following behaviors previously found to succeed. According to [14], due to the largely Western and individualistic perspective on management and leadership, the extent to which Western leadership and business theories apply globally is being questioned.

Therefore having a representation of Competency model can help organizations align their initiatives to their overall business strategy. By matching competencies to business strategies, organizations can better recruit and select employees for their organizations.

Factors affecting Skills and Competencies can be divided into two categories: 1. Intrinsic/Internal factors and 2. Extrinsic/External Factors. Business acumen skills such as communication, teamwork, organization, numeracy needed to perform a job can be affected by internal factors (intrinsic) or external factors (extrinsic).

A. Internal/Intrinsic Factors: These are those factors that are not dependent on external conditions. They are inherent, located within the work force and the individual learners or workers. Self-Esteem, Skill recognition, Confidence, Competency, Progression, punctuality, consistency, self-awareness and proactiveness among others, are examples. Individuals perform better in business when they are strategically placed in a job. One of the ways is having these individual traits built in an occupational profiles for specific jobs as well as identifying individual differences, matching individuals to occupations based on these differences, can improve the level of competency though a formal assessment. When individuals are appreciated via rewards, promotions and other incentives, their psychological needs are met and their state of mind (mental/cognitive ability) is fully dedicated to achieving more.

B. External/Extrinsic Factors: These are factors that are not inherent; they act from the outside of the company or business. Examples are economic provisions, incentives, work space, physical environment, management, organizational structure and so on.

Several of these factors can affect teaching and Learning of business acumen both in the real and virtual world. [15] categorized the above factors as follows

A. Economic Factors- the gap between developed countries and developing countries can affect the way business is done. All of our career choices and decision about skill to pursue takes place within the context of society and the economy. Changes in the economy and resulting job market also affect how certain skills are developed.

B. Environmental- This is particularly extrinsic. A desirable healthy and aesthetically appealing atmosphere is soothing and comforting. It is liable to promote emotional
harmony and balance. On the contrary, an unhealthy environment can become a source of many emotional upset and disturbances.

C. Social Factors- Education reflects the cultural differences and social pattern of society and this also can determine the degree of skills acquired within a cultural setting

D. Linguistic Factors- Language is one of the natural factors that helps and influences growth of the educational system of a country.

These factors are often ignored by business game designers due to its complex nature or unavailability of architectural tools. Several researches in the context of the Architecture, Engineering and Construction (AEC) domain of Serious Games (SGs) such as Business Game. This requires domain-specific knowledge, usually represented by domain-experts (civil engineers and architects) as part of the game development team. [16]. A challenging task of the design process is the creation of game objects to model the game world. These game objects are based on common western or developed AEC objects (like wall, floor, window, door etc.). Additional information about objects role and skills they present in the game scenario has been a challenge for game designers.

IV. APPLICATION OF ONTOLOGY

There are different principles, methods and applications of Ontologies hence the role of formal languages and techniques in the specification implementation cannot be overemphasized. The world comprises not only things, animate or inanimate, but also activities and processes and the products that derive from them. It is likewise difficult to deny that there are thoughts, sensations and decisions, and the entire spectrum of mental activities. The study organized items of the world as:

- Independent items that may be real (mountains, flowers, animals, and tables),
- Independent ideal (sets, propositions, values),
- Dependent real (colours, kisses, handshakes and falls) and
- Dependent Ideal (formal properties and relations)

Descriptive ontology concerns the collection of such information either in some specific domain of analysis or in general. Formal ontology distills, filters, codifies and organizes the results of descriptive ontology in either its local or global setting [17][18].

Table 1 presents the categories and uses of Ontology into six (6) broad areas:

<table>
<thead>
<tr>
<th>S/N</th>
<th>Category</th>
<th>Example of Implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Web Portals</td>
<td>searching algorithms and techniques</td>
</tr>
<tr>
<td>2</td>
<td>Multimedia Collections</td>
<td>context based searching</td>
</tr>
</tbody>
</table>

V. GAME ONTOLOGY MODEL FOR BUSINESS SKILL (GOMBS) THEORETICAL FRAMEWORK

Figure 1 presents the theoretical framework for this work. There are four major elements of focus namely: Business Skills, Influencing Factors, Game Ontology Project (GOP) and Ontology of Business Games. The classifications and examples of business skills needed in a developing country environment were used repeatedly as variables to determine what factors (intrinsic and extrinsic) and environment dynamics that can affect these skills and competency levels. In other to present these acquired skills and competency level, a game ontology is required to formalize all elements as it relates to skills are inherent in a particular business environment setting or game scenario. This stage will be processed severally to validate and align skills with appropriate game level. The outcome of the continuous processing of the ontology elements was then used as individual data property rules to build the business game ontology.

VI. RELATED WORKS

Reference [19] used four steps to specify the ontology of skill and competency: (a) provide a motivating scenario; (b) define informal questions to capture the scenario (i.e. scope); (c) define the terminology (i.e. predicates); and (d) define the
axioms (i.e. semantics). The study represented and measured skill and competencies in a descriptive logic thus:

A skill at a particular level of proficiency enables a set of activities:

\[ \forall s. \text{skill}(s) \implies (\exists a, f, \text{activity}(a) \land \text{proficiency-level}(l) \land \text{knowledge-field}(f) \land \text{skill}(s)) \land \text{in-field}(a, f). \]

Q-6. Should a source \( X \) be trusted with respect to information about skill \( S \)?

Example 1: \( \exists r \) trusted-in(X, f) \land in-field(S, f).

Example 2: \( \exists r \) measures skill(X, S, f).

The in-field predicate relates a particular skill to the knowledge-field that it belongs to, and is later used for asserting skill statements about individual using information from sources that are trusted in the related knowledge field as shown in Figure 2.

Fig. 2. Sources of skill and competency information [19].

Reference [16] worked on the context of the Architecture, Engineering and Construction (AEC) domain of Serious Game such as Business Game. The research approach tried to retrieve most of the required knowledge automatically from a knowledge base (KB).

This KB consists of digital content, which is already created during the Building Information Modeling (BIM) process. The challenge here is how to interpret the information from the expert into a computer system.

Reference [20] worked on Role Play Games (RPG) used Resource Description Framework (RDF) and presented a faster approach in modeling RPGs by exploring the organizations of elements using greedy algorithm.

Game Ontology Project is a new area (as of 2015) and therefore many works done so far are mostly literature review and only a few Ontologies have been built.

Ontologies like that of [19] on Environment assessment as a source is completely missing in the works attempted by Game Ontologists, whereas research has shown that environment is an all-important assessment source which plays a role in skill and competency learning levels and growth over time [21] [22] and [23]. Also Set of Skill Statement is probable because it is based on trust. Trust in itself is not symmetric [24] and Trust ontologies have been made before [25], but not based on a comprehensive analysis. The trust-in predicate was used denoting that the agent (the organization) trusts an information creator. This alone corresponds to an external process to make just judgments which will only return true if trust relationship holds and otherwise returns false.

\[ T-9. \forall o, r, p, x, l. \text{occurrence-of}(o, \text{declares}(r, p, s, l)) \land \neg p \in \text{in-field}(s, f) \land \text{trusted-in}(r, f) \land \neg \text{prior}(\text{demonstrated}(\text{skill-statement}(p, s, l)), o) \land \neg \text{prior}(\text{refuted}(\text{skill-statement}(p, s, l)), o) \land \text{achieved}(\text{probable}(\text{skill-statement}(p, s, l)), o). \]

Individuals can declare positive or negative skill statements about themselves or others. We represent this by activities \( \text{declares}(r, p, s, l) \), indicating agent \( r \) has stated that agent \( p \) has skill \( s \) at level of proficiency at least \( l \), and \( \text{declares-neg}(r, p, s, l) \), indicating a negative declaration Environment as Information Source as for Skill check was corrected in this work by generating an ontology which accommodates Environmental influence as a major factor and also uses a domain descriptive logic as an assessment ontology module to filter trust and false skill set declaration.

In [16] and [20], greedy algorithm implemented is not flexible for complex architectural levels of serious games such as a business game where linking of data sources (as shown in Figures 2 and 3) in a coherent manner has become more important. These sources were not interlinked making automatic updates as per changes in occurrences difficult. This work corrected this error using the GOBMS to filter Skill Set, mapping rule via Web Semantic Mapping Language (WSML), and Dynamic Game Level Balancing (DGLB).

VII. THE PROPOSED ONTOLOGY

In other to build ontology for business games the standard four basic steps from the recommendation by [26], were adopted. These are the four basic steps:

**STEP 1. Define the Purpose of the Business Game Ontology**

In this work we identified the purposes of business game ontology which are to:
1. Present a formal model for the treatment and interpretation of the gameplay in order to solve communication and interoperability problems.
2. Knowledge sharing platform for business game designers.
3. To reduce time and money wasting by enabling reuse of resources and tools as it is related to gameplays.

Various elements and object classes were created in protégé based on learning purpose as shown in figure 4 and 5. For example. Scenario Entry rules and level mechanics will determine the job vacancies, or starting level and so on. In this work, the interoperability problem is resolved by using a Web Service Modeling Language (WSML) mapping rule to associate Skill objectives specified in subclasses and domain ranges.

![Fig. 3. Purposes /Contextualization Business Game Ontology](image-url)
STEP 2. Ontology Conceptualization

This represents the Knowledge Modeling (KM) itself. In this ontology’s scope, relations and constraints descriptions of glossaries are included. Competency questions which the ontology must answer

A. These are the question the concept must answer

1. What will be the business components?
2. Are there business and pedagogical rules?
3. What are the associated elements of the developing country (example physical environment conditions)?
4. What are the skills and competencies to be mapped to actions, goals and rules?
5. Can these skills be mapped to conditions, actions or task?

This work focuses on Conceptualization questions 4 and 5.

B. Individual Skill Statement Ontology:

In this work we have classified the skills domain into three, namely:

- Technical skills:
  In the developing country context we have attached economic factor. This skill entails the ability to use available technical equipment and the level of improvisation. Proficiency is usually required to achieve this skill. Some of the technical skills represented as individual numeracy, software proficiency
- Human skills
  Interpersonal relationships such as team work, customer relations and Situation understanding is another skill that has been built it. Human engineering goals and communication goals are on this skill. It has been mapped to social and linguistics factor goals and pedagogical goals as shown in Figures 4 and 5

- Conceptual Skills
  In this skill, the needed goal is the ability to see long range business deals as well as plans, and to make right choices during changes in environment, cost and so on. This rule is linked mostly with Environmental and Economic

Acquiring above skills is part of rules (subclasses to domains) which will come with various tasks to be accomplished in a specific game scenario (financial tasks, marketing tasks, communication task and so on). The ontology has formalized varying propositions of these skills at each task. These set of skills are shown in Figure 5.

STEP 3. ONTOLOGY FORMALIZATION

Ontologies can be expressed adopting different formalisms, called also description languages. Description logics belongs to a family of knowledge representation formalisms which are decidable subset of the First Order Logic (FOL). The description logics are distinguished by different sets of constructors of concepts (union, intersection, universal and existential quantifier, and so on and rules (inverse rule, transitive rule, concepts subsumptions).

In order to view inferred classes about skills and pedagogical goals via OWLViz Plug-in and ease implementation in JENA framework, sample classes were created under each skill such
Where individuals can declare positive or negative skill statements about themselves or others; To correct this issue of false skills declarations by individuals as shown in [19], the work represents this by using activities declares \((r, p, s, l)\), indicating agent \(r\) has stated that agent \(p\) has skill \(s\) at level of proficiency at least \(l\), and declares-neg \((r, p, s, l)\), indicating a negative declaration;

\[
\exists o, a \text{ occurrence-of}(o, a) \land ((\exists l, t \text{ a = passes}(P(t)) \land \text{measures-skill}(s, t, l)) \lor
(\exists l, t \text{ a = declares}(r, P(s), l)) \land \text{prior}(\text{refuted}(\text{skill-statement}(P(s), L)), o), o).
\]

Two Ontological aspects required for these corrections to be made are:

1. **GameSkillOnt** - this is set of semantically organized game skill statement containing the player attributes. Ontology such as Player Names (Full Names and Game Usernames), game skills (technical, human and conceptual skills), Eligibility and experiences (Proofs), game competency level and PlayerReferee are automatically saved here. For example, this GameSkillOnt can be like a Game player account provided by Google Game Play, Online Player Game Specific Game Box Card

2. **GameReqOnt** - this is the set of requirements needed for a game to be played; it could be content-based game descriptions; gameplay rules and/or game-world rules. Some of the rules are ‘a must have-constraints or exceptions’ declared as numbers (integers, float) or string exceptions. Example: \(\text{Ratings}_{\text{int}}, \text{Age}_{\text{int}}, \text{GameCardNumber}_{\text{longint}}, \text{or Country}_{\text{string}}\). See Figure 8 for more properties.

Now using Description logic (DL) to formally represent GameSkillOnt profile and GameReqOnt

Note: The DL is the basis used in Dynamic Game Balancing (DGB)

\[
\text{GamePlayer} = \text{Person} \sqcap \exists \gamma \text{hasGameSkillStatement}.\text{GameSkillStatement}
\]

where GameSkillStatement is thus represented

\[
\exists \gamma \text{hasGameSkillStatement.}\text{GameSkill} \sqcap
\exists \gamma \text{hasGameCompetencyLevel} \sqcap
\exists \gamma \text{hasGameProof}.\text{GameProof}
\]

where \(\text{hasGameCompetencyLevel}\) contains the set of which are usually represented as integers or range of numbers.

For a Game to be activated by the player, there are Requirements in the form of:

\[
\text{GameRequirement} \sqcap \exists \gamma \text{hasGameRequirement}.\text{Requirement}
\]

Note Requirement can either be Eligibility or Game Skill Requirement

\[
\text{GameRequirement} = \text{Requirement} \sqcap
\exists \gamma \text{requiresEligibility}.\text{PlayerProfile} \sqcap
\exists \gamma \text{requiresPlayerReferee} \sqcap
\exists \gamma \text{requiresProof}.\text{GameProof}
\]

\[
\text{GameSkillRequirement} = \text{Requirement} \sqcap \exists \gamma \text{requiresGameSkill}.\text{GameSkill} \sqcap
\exists \gamma \text{requiresGameCompetencyLevel} \sqcap
\exists \gamma \text{requiresEligibility} \sqcap
\exists \gamma \text{requiresGameExperience}
\]

So to represent a competency together with skills we have:

\[
\text{CompetencySkillLevel}: \text{GameProof} \sqcap \exists \gamma \text{hasPlayerName}.\text{PlayerProfile}
\exists \gamma \text{hasTechnicalSkill},\text{PedagogicalGoal} \sqcap
\exists \gamma \text{hasHumanSkill},\text{PedagogicalGoal} \sqcap
\exists \gamma \text{hasConceptualSkill},\text{PedagogicalGoal} \sqcap
\exists \gamma \text{hasEnvironmentalChange},\text{GameEnvironment}
\]

The Ontology showing environment changes is generated by creating several classes to and objects to represent the changes in weather, changes in object interactions, work environment and so on. Figures 7 and 8 adapted from [27] [28] to present relation between Game environments and Game rules, tasks and skills.
STEP 4. ONTOLOGY VALIDATION

For knowledge to be inferred properly, it is necessary to use OWL Validator (such as Hermit, OWL Reasoner, Konclude, FaCT++, Pellet, JFact) to validate ontologies written in RDF/XML, OWL/XML, OWL Functional.

VIII. THE ACQUIRED SKILL AND THE APPROPRIATE GAME LEVEL

In other to evaluate a skill set with appropriate environment and competency determinant factors which are presented by environment change data property. The study applied a Dynamic Game difficulty Balancing, also known as Dynamic Difficulty Adjustment (DDA) or Dynamic Game Balancing (DGB). In this process, skills sets were classified to automatically change parameters, scenarios, and behaviors in a business games in real-time, based on the player's ability, in order to avoid them becoming bored (if the game is too easy) or frustrated (if it is too hard). Traditionally, game difficulty increases steadily along the course of the game (either in a smooth linear fashion, or through steps represented by the levels). The parameters of this increase (rate, frequency, starting/entry levels) can only be modulated at the Expert Profile level where the user can create or select an environment (as shown in Figure 6). Still, this can lead to a frustrating experience for both experienced and inexperienced gamers, as they attempt to follow a preselected learning or difficulty curve. The ontology, if well implemented by the game designer remedies this issue by creating a well-balanced experience for each gamer. As the users' skills improve through time (as they make progress via learning), the level of the challenges and factors affecting competency in real time also continually increases.

IX. CONCLUSION AND RECOMMENDATION

Business Games are needed to enhance the business skills and improve the way people do business; therefore all factors (intrinsic and extrinsic) must be captured during the design process. These factors affect the skills and competency level and so capturing them during design retains the original essence found in business environment especially in a developing country setting. Though this is a challenging task on the side of the design experts who usually will abandon these factors leaving the existing business to distort the reality of running business, an ontological approach has proven to be the best way to proffer solution to this challenge. This work ontologically defines business game internal and external factors and the instances created towards equivalent skill set. Skills and Competencies will be better matched to business strategies, organizations and environment. The outcome of this work will serve three major beneficiaries:

a. Trainees/Students: Students or Trainees will be trained with a first-hand EdTech simulation tool that represents the ideal of running business in a developing country and the relationship between the peculiarity of environment and the skills needed.

b. Instructors/ Teachers/ Institutions: Instructors, Teachers and Training Institutes will save cost used in running manual labs as Business Game designed from this ontology will be a virtual business learning environment that will align appropriate business acumen in developing countries.

c. Business Policy Makers/ Businesses Managers: When a fresh employee has been trained at the undergraduate level, employers will save resources (time, money and so on) used in employee education and retraining. On the other hand, better business policies will be formulated to enrich business practices and global economy.

With the Dynamic Game balancing (DGB), the Business Games Ontology presented here aligns competencies and skills within equivalent Game experiences thereby serving as teaching aids on how to accomplish business acumen in the developing countries.