Agile Model to Sustainable Design and Construction for Schools in Developing Countries

M. A. Ibrahim[1], H. S. ElBehairy[2], A. M. Nagy[3]

1 Professor, 2 Assistant Professor, 3 Ph.D. Candidate
Civil Engineering Department, Faculty of Engineering, AL-Azhar University, Egypt

Abstract— The main goal of this research is to progress approach to apply sustainable requirements to design criteria and construction phase of schools using an Agile model based on reference guide Leadership in Energy and Environmental Design version 4 for Building Design and Construction ($LEEDV_4$ BD+C) requirements. The Agile model delivers the sequence for phases, steps and activities necessary to take a systems approach for the project. The Agile model depends on applying the most fundamental requirements, at first to attain the minimum sustainability requirements, then releases and delivers it, then starts a new iteration cycle of Agile to add another items and develops the existing design and construction by getting a feedback from school users. The proposed a model consists of seven iterations to achieve the ($LEEDV_4$ BD+C) certification in the design and construction of schools to be sustainable the name of model is Agile Model and Integrated Sustainable Design and Construction of Schools (ASDCS).

Keywords— Sustainable Design and Construction, Schools, Agile Model.

1 Introduction

Construction industry impacts the environment not only out of its produce, but also during the implementation. Buildings deplete almost about 45-50% of energy and 50% of water resources [1]. Applying sustainability in the construction becomes very wide during the last decade, especially in developed countries. Schools are considered one of the most important construction, where the education plays an important role in the development of society. Applying sustainability in the design and construction of schools achieve many benefits like decreasing undesirable environmental effects, conservation of natural resources and enable teaching staff and students to achieve better results, this kind of schools have a sustainable infrastructure and buildings, according to ($LEEDV_4$ BD+C) requirements. This research presents an approach for the application of sustainable design and construction of schools using the Agile model, to reduce and contribute to the environmental effects to the construction industry. Agile model is not restricted to a special industry, process or application, the models are used as a road map with flexibility for changing internal and external variables [2]. Implementation Agile model in the construction project can give a share in the sustainability and to the decrease of the construction industry's impacts on the environment through its outputs and its process. Application of Agile model for sustainable design and construction of schools gives several advantages to a project team. Employing a model provides the decision makers with a common model that sequences the steps required to finish the project, this method, ensures that needed actions are accomplished with an understanding of the succession [3]. Agile model is prescriptive in nature in providing a systematic approach with guidelines to establish the uses that can be applied by an organization at different locations and by persons of variable skill levels [4]. Energy efficiency and environmental criterion are needed to apply the process model system traceability and optimum over the sustainable design and construction process. Systems engineering process models have demonstrated effectiveness for applying an integrated and overall view of process models which allow for clear decision maker participation, requirements definition, life cycle analysis, effectiveness and investigation [3]. Tomek studied the effect of the construction industry by applying building information modeling (BIM) and Agile project management, where the focus was on economic incentives of their implementation for bringing in the additional benefits. Both tools lead to develop integration general model to output and process the site management stage of a construction project [5]. Nowotarski and Paslawski presented an approach to improve quality during the implementation of IT process based on the management of the projects by agile management [6]. Gonzalez proposes a theoretical model to improve agile project management to create and manage the development of intellectual property. The study findings revealed indication on intellectual stuff projects relating agile project management, such as computer software and training tools and other intangibles. The theory for the developed model is according to hypotheses condensed from the previous studies, such as environments knowledge, improvement networks, and Agile approaches. The research also presents a new correction for the operative application of a developed Agile project management method, cheering an imaginative and methodical methodology for applying the Agile model to manage projects [7].

2 Sustainable Construction Requirements for Schools

The U.S. Green Building Council defined the term "sustainable schools" is the ability of schools to availability of healthy environment contributory to learning as well as saving energy, cash and resources [8]. Among all public buildings, on account of their educational purpose, schools have a major social responsibility. Therefore, energy performance in these types of

buildings has a great importance. Educational facilities are a vital field to implement the sustainability practices and energy efficiency programs. The environmental air quality is an essential part that should be considered through the design and construction stages [9]. Design and construction of schools to sustainable approach gives many benefits to occupants, where including according to (LEEDV$_4$ BD+C) reference guide for green building design and construction of main six goals: Location and Transportation (LT) 15%, Sustainable Sites (SS) 12%, Water Efficiency (WE) 12%, Energy and Atmosphere (EA) 31%, Materials and Resources (MR) 13%, and Indoor Environmental Quality (IEQ) 16% as shown in (Fig. 1) [10].

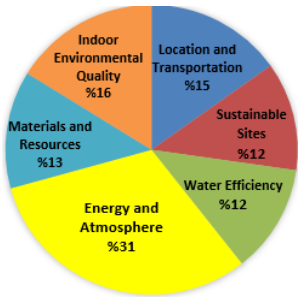

Fig. 1. (LEEDV$_4$ BD+C) System Goals for schools [10].

Location and Transportation (LT) rewards thoughtful decisions about building location, with credits that encourage built-in improvement, connection with amenities and options of alternative transportation as parks and restaurants [10].

Sustainable sites (SS) is a category highlights on rewards decisions about the environment surrounding the building, with credits that make sure the active relationships between buildings, and ecosystem services. It's highlight on the project site elements, merging the site with local and regional ecosystems, and preserving the biodiversity that natural systems rely on [10].

Water Efficiency (WE) is a category addresses water comprehensively, looking at indoor use, outdoor use, specialized uses, and metering. It is according to an "efficiency first" approach to water conservation [10].

Energy and Atmosphere (EA) is a category approaches energy from a complete viewpoint, focusing on reducing energy use, energy saving design approaches, and renewable energy sources. Efficiency of energy in sustainable building beginning with a highlight on design that decrease total energy requirements, for example building orientation and glazing selection [10].

Materials and Resources (MR) is a category highlights on reducing the embodied energy and other effects related to the extraction, managing, transport, maintenance, and dealing with demolished building materials. The requirements are designed to support a life-cycle attitude to develop the performance and promotes resource effectiveness [10].

Indoor Environmental Quality (IEQ) is a category that highlights about indoor air goodness and thermal, visual, and acoustic comfort. Sustainable buildings with a better indoor environmental quality keep the health and relief of building user. First-class indoor environments also improve efficiency, absence reduction, develop the building's value, and decrease responsibility for building designers and owners [10].

3 (LEEDV$_4$ BD+C) CERTIFICATION

The (LEEDV$_4$ BD+C) certification system is the most preferred green building certification system in the world, and has been progressing in the United States set by Green Building Council [11-12]. The (LEEDV$_4$ BD+C) certification system heavily relies on United States codes, standards and regulations, which limit its applicability and success in other countries [11-13]. (LEEDV$_4$ BD+C) certification for sustainable construction requirements for sustainable buildings are awarded to four levels as shown in (Fig. 2).

Fig. 2. Certification of (LEEDV$_4$ BD+C) [10].

The significant construction processes that earn credits, and ultimately produce a sustainable project, include storm water management, construction waste management, material procurement, and indoor air quality [14]. (Fig. 3 and 4) shows the (LEEDV$_4$ BD+C) for Building Design and Construction checklist and credits required for schools.

LEED v4 for BD+C: Schools
Project Checklist
Project Name
Date

Y	?	N			
			Credi 1	Integrative Process	1
			Location and Transportation	**Possible Points:**	**15**
			Credit 1	LEED for Neighborhood Development Location	15
			Credit 2	Sensitive Land Protection	1
			Credit 3	High Priority Site	2
			Credit 4	Surrounding Density and Diverse Uses	5
			Credit 5	Access to Quality Transit	4
			Credit 6	Bicycle Facilities	1
			Credit 7	Reduced Parking Footprint	1
			Credit 8	Green Vehicles	1
			Sustainable Sites	**Possible Points:**	**12**
			Credit 1	Site Assessment	1
			Credit 2	Site Development--Protect or Restore Habitat	2
			Credit 3	Open Space	1
			Credit 4	Rainwater Management	3
			Credit 5	Heat Island Reduction	2
			Credit 6	Light Pollution Reduction	1
			Credit 7	Site Master Plan	1
			Credit 8	Joint Use of Facilities	1
			Water Efficiency	**Possible Points:**	**12**
			Credit 1	Outdoor Water Use Reduction	2
			Credit 2	Indoor Water Use Reduction	7
			Credit 3	Cooling Tower Water Use	2
			Credit 4	Water Metering	1

Fig. 3. Checklist for Schools Design and Construction as per (LEEDV$_4$ BD+C) Standards for (LT), (SS) and (WE) [10].

LEED v4 for BD+C: Schools
Project Checklist
Project Name
Date

Y	?	N			
			Energy and Atmosphere	**Possible Points:**	**31**
			Credit 1 Enhanced Commissioning		6
			Credit 2 Optimize Energy Performance		16
			Credit 3 Advanced Energy Metering		1
			Credit 4 Demand Response		2
			Credit 5 Renewable Energy Production		3
			Credit 6 Enhanced Refrigerant Management		1
			Credit 7 Green Power and Carbon Offsets		2
			Materials and Resources	**Possible Points:**	**13**
			Credit 1 Building Life-Cycle Impact Reduction		5
			Credit 2 Building Product Disclosure and Optimization - Environmental Product Declarations		2
			Credit 3 Building Product Disclosure and Optimization - Sourcing of Raw Materials		2
			Credit 4 Building Product Disclosure and Optimization - Material Ingredients		2
			Credit 5 Construction and Demolition Waste Management		2
			Indoor Environmental Quality	**Possible Points:**	**16**
			Credit 1 Enhanced Indoor Air Quality Strategies		2
			Credit 2 Low-Emitting Materials		3
			Credit 3 Construction Indoor Air Quality Management Plan		1
			Credit 4 Indoor Air Quality Assessment		2
			Credit 5 Thermal Comfort		1
			Credit 6 Interior Lighting		2
			Credit 7 Daylight		3
			Credit 8 Quality Views		1
			Credit 9 Acoustic Performance		1

Fig. 4. Checklist for Schools Design and Construction as per (LEEDV$_4$ BD+C) Standards for (EA), (MR) and (IEQ) [10].

4 Event List for Each Goal of Sustainable Design and Construction

An event list for sustainable design and construction of sustainable buildings was aggregated as the sustainable building schema based on integration of best practices across construction industry. This research uses the events for tasks that are mapped to the Agile model. The sustainable design and construction outlined in this research and mapped to the Agile model are: first vision, (LEEDV$_4$ BD+C) criteria, sustainable design criteria, schematic design, integrated design, sustainability modeling, design development, tender documents, construction, submission, and finally acceptance / rejection.

First vision ties the requirements and sustainable strategy into a direction for the facility. The public can be included as participants, as appropriate. This early planning meeting is critical to setting the stage for attaining the sustainable strategy [15].

(LEEDV$_4$ BD+C) criteria is the common sustainable building certification standard within the United States. The (LEEDV$_4$ BD+C) was developed by the US High performance building Council. The certification standards give a checklist and possible points scale to determine the certification levels for sustainable design and construction of schools [10].

Sustainable Design Criteria are the requirements that highlight on increasing energy efficiency for the educational building and integrate the renewable energy sources. In addition to a several other requirements for the sustainable design for which performance criteria might need to be established to include, indoor air quality, structural and architectural elements, material usage, waste management, manufacturing applications, etc. Design criteria are confirmed to achieve the targeted level of sustainable education building certification.

Schematic Design is the theoretical design which is applied to drawings and documentations that can be modeled and calculate costs as necessary. The schematic design has confined detail, still must add adequate data for analysis of alternatives, user acceptance, systems integration and regulatory approvals are required. Design decisions from the theoretical design to the schematic and detailed design have an impact on the environmental, energy usage and overall performance of the sustainable building [16].

Integrated Design shall start in the planning phase and continues during all building life cycle stages for each item work and for all parts of building.

Sustainability modeling the computer based programs are used to analyze the sustainability requirements of the planned building and its components. For the greatest effect sustainability modeling should begin early in the design process where it can influence the design and then be advanced as the design matures.

Design Development is the detailed design drawings, specifications and documents are prepared to include all disciplines (architectural, structural elements, electrical, mechanical, and fire protection) based on sustainable requirements of educational building.

Tender Documents includes the drawings, specifications and documents with the addition of the contract administration procedure, contract terms and bidding research. This is the set of information that is used for bidding and proposal purposes.

Construction of sustainable building to include site work and location. Additional sustainable aspects of construction include waste management, emissions and material transportation [17].

Submission is the final stage wherein the project team has finished the sustainable educational building included with documentation, testing, measurement, verification and validation. This stage is to deliver the project to the decision maker.

Acceptance / Rejection the decision maker will check all specifications, drawings, and all presented data then review it with (LEEDV$_4$ BD+C) requirements of school's design and construction, if this data approved it will be accepted, if not it will be rejected with notes or fully rejected, and then starts a new cycle of design.

5 Agile Model

Agile word is one of the trendy concepts of this century. The Agile model is a key component to get the organization advantage and interest brought by agility and overcome the mutual

Issues found on the adoption process [18, 19]. Agile development monotonous are marked by observable features, such as the time or duration of their occurrence, the number and functions of their participants, or the outcomes they output. They are distinguishable not only versus non-routinized activities, but also versus other monotonous. These features are most popular in so-called Agile development method, which display an increased focus on flexibility [20]. Agile projects propose and give one or more iterations and get the feedback ,then deliver the complete product at the end of the final iteration. (Fig. 5) Shows Agile model iteration life cycle [21].

Fig. 5. Agile Model Iteration Life Cycle [21].

Phases of iteration life cycle of Agile model include ADDIE stags as the flowing:

Analysis stage it is the first stage which the planner identifies the issue, the objectives, the user needs, existing knowledge, and any other related characteristics.

Design stage gives ideal method design and systematic improvement of the project. Design stage include goals, content, instruments evaluations, subject analysis, and project planning. Design process makes the project and cover planning, implement and give the evaluation for the final product [22].

Development stage is where the planners make and collect the content assets that were created in the previous design stage. Planners work to improve and integrate technologies. Testers implement correcting procedures. The product is checked and revised according to the received feedback.

Implement stage gives more methods than simply submitting the materials developed. Whereas the notion and checked materials throughout the process, the implementation stage displays topics that need further development or re-analysis and design. The processes for this stage vary due to the project size, the complication of the project, and the allocation of the materials.

Evaluation Stage is continuous through the design stage. Its goal is to ensure that all goals of the process will achieve the specific needs. Another objective of this phase is to identify the performance work after finishing the cycle, and ensure that the project requirements has been achieved.

Agile methodology divides each project in plan to several items, the development team will set the basic and important features of this items that are needed in the project and decide which of these features can be developed in the first iteration, remaining features that cannot be carried out in the first iteration will be taken up in the next iteration or next iterations. According to the priority as shown in (Fig. 6). This methodology allows the user to interrelate and work with the model at the end of each iteration and provides a feedback.

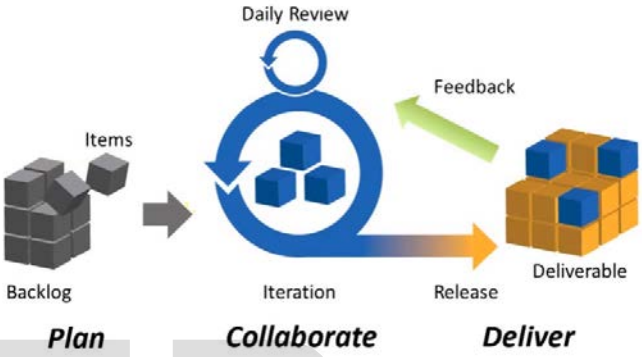

Fig. 6. Agile Model [21].

This methodology gives users to take up changes more easily and make path corrections if needed. Traditional methodology considered each act task does its act and hands over to the next act task. The previous act tasks have to sign off before it is handed during the coming act task notarized that the act is full and complete in all aspects. For example, requirement collecting is completed and delivered to design stage and it is thereafter delivered to improvement and later to testing and rework. Each act task is a stage by itself. In Agile method of working, each trait is finished in terms of design, development, code, testing and rework, before the trait is called done. There aren't isolated stage and all the work is done in one stage only. Agile model has a lot of benefits and defects that can summarized in the flowing pontes [21].

- **Agile Advantages:**

- The Agile life cycle of the delivery to a project is continuous.
- The user delivered updated project after every iteration.
- Users can have a look of the working feature which achieved their anticipations.
- The users' feedback then taken into consideration in the next iteration.
- The requirements change is received even in later stages of the development.

6 Agile Model and Integrated Sustainable Design and Construction of Schools (ASDCS)

The Agile model applied with the mapping for the design and construction of sustainable schools (ASDCS) are shown in (Fig. 7), the mapping shows Iteration (1) life cycle of the model. Which the Agile model does well for use with non-complex facilities as well as for use by teams with limited experience, newly formed teams and junior engineers. Extensive documentation is completed with the end of each iteration of the Agile model. After the requirements are set to include the sustainable strategy with performance criteria to design and construction of sustainable schools, the next phase occurs for the integration of the systems with the iteration life cycle that lead to be delivered to the decision make. The first iteration with minimum requirements for applying sustainable design and construction of schools. The second iteration updates the first iteration based on decision maker feedback and add a new feature to improve the sustainability certification of the schools. The third iteration is similar to the second iteration till the building achieves the highest certification of sustainability. The number of iterations depends primarily on the decision-maker requirements and his finance resources provided to achieve the highest certification of sustainability requirements of design and construction of schools.

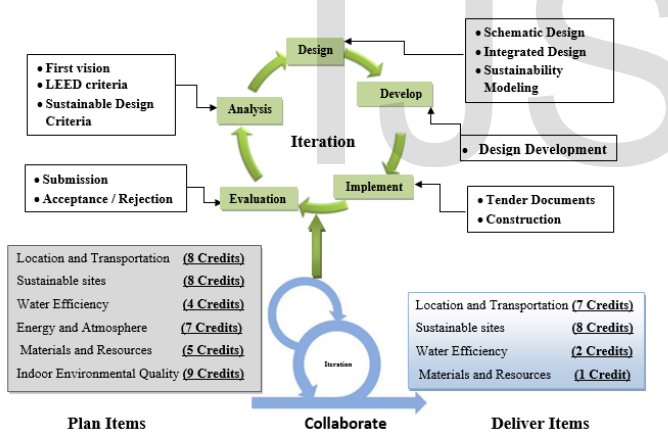

Fig. 7. (ASDCS) Mapping of Applying Sustainable Schools Construction to Agile Model Iteration Number (1).

The Later iterations for applying the sustainable design and construction to schools using Agile model (ASDCS) is indicated with a clear format in (Table 1), which indicates the (LEEDV$_4$ BD+C) requirements and its credits required for schools to each goal, the number of Agile iterations applied and delivered to decision maker one by one. The credits items number for each goal is indicated in (Fig. 3 and 4). The total points give certify based on (LEEDV4 BD+C) certification as shown in (Fig. 2), this certify devolved after each iteration of Agile model.

7 Conclusion

The current changing nature of sustainable design and construction criteria is an ideal candidate for applying proven Agile models. This research development of a life cycle to high performance building of school's event list and schema provides a framework that can be used to enhance and further performance of a project team and ultimately the designed and constructed facility. The research provides a tool for applying the Agile model to design and construction proses of schools to make it applied in a simple model format (ASDCS) to apply in the developing countries due to the lack of financial resources and shortage of skilled labors for this type of constructions. The criteria presented in this research based on (LEEDV$_4$ BD+C) requirements for school's design and construction. Agile applied the sustainable schools through several iterations as it indicated in the research.

TABLE 1
AGILE ITERATIONS FOR APPLYING A SUSTAINABLE CONSTRUCTION TO SCHOOLS

LEEDV4 BD+C Requirements	Credits for Schools	Agile Iteration	Delivered	Credits No. applied	Points	Total Points	Certify
Location and Transportation	8	1 (Fig.7)	Location and Transportation	1,2,3,4, 5,6,7	15	41	Certified
Sustainable sites	8		Sustainable sites	1,2,3,4, 5,6,7,8	12		
Water Efficiency	4		Water Efficiency	1,2	9		
Energy and Atmosphere	7		Materials and Resources	1	5		
Materials and Resources	5	2	Water Efficiency	3,4	3	52	Silver
Indoor Environmental Quality	9		Materials and Resources	2,3,4,5	8		
		3	Energy and Atmosphere	1,4,6,7	11	63	Gold
		4	Indoor Environmental Quality	1,2,3,4	8	71	Gold
		5	Indoor Environmental Quality	5,6,7,8, 9	8	79	Gold
		6	Energy and Atmosphere	3,5	4	83	Platinum
		7	Energy and Atmosphere	2	16	100	Platinum
			Location and Transportation	8	1		

References

[1] Chan APC, Chan DWM, Fan LCN, Lam PTI, Yeung JFY (2008) "Achieving partnering success through an incentive agreement," lessons learned from an underground railway extension project in Hong Kong. J Manag Eng ASCE 24(3):128–137.

[2] M. P. Bhave, "A Process Model of Entrepreneurial Venture Creation," Journal of Business Venturing, vol. 9, p. 223, 1994.

[3] Bersson, F.T., (2012) "A Framework for Application of System Engineering Process Models to Sustainable Design of High Performance Buildings," Doctor of Philosophy, Faculty of the School of Engineering and Applied Science George Washington University, USA.

[4] Blum, B., I., "A Taxonomy of Software Development Methods", COMMUNICATIONS OF THE ACM, vol. 37, pp. 82-94, 1994.

[5] Tomek, R., I., 2015. "Agile PM and BIM: A hybrid scheduling approach for a technological construction project," Creative Construction Conference 2015, Procedia Engineering 123 (2015) 557 – 564. www.sciencedirect.com
[6] Nowotarski, P., Paslawski, J., 2015"Barriers in running construction SME – case study on introduction of Agile methodology to electrical subcontractor," Operational Research in Sustainable Development and Civil Engineering - meeting of EURO working group and 15th German-Lithuanian-Polish colloquium (ORSDCE), Procedia Engineering 122 (2015) 47 – 56. www.sciencedirect.com
[7] Gonzalez, W., (2011) "Agile Project Management and the Creation of Intellectual Property," Doctor of Philosophy, University of Maryland University College, USA.
[8] Lysgaard, J.G., Larsen, N., Læssøe, J., 2015. "Green flag eco-schools and the challenge of moving forward. In: Responsible Living," Springer International Publishing, Cham, Switzerland, pp. 135e150.
[9] Pereira, L.D., Raimondo, D., Corgnati, S.P., da Silva, M.G., 2014. Energy consumption in schoolsea review research. Renew. Sustain. Energy Rev. 40, 911e922.
[10] U.S. Green Building Council. Accessed 5 April 2016. http://www.usgbc.org/.
[11] Potbhare, Varun, Syal, Matt, Arif, Mohammed, Khalfan, Malik M.A., Egbu, Charles., "Emergence of Green Building Guidelines in Developed Countries and their Impact on India", Journal of Engineering, Design and Technology, Vol. 7, No. 1, 2009, pp. 99-121.
[12] R. Komurlu, D. Arditi, A.P. Gurgun, "Assessment of LEED requirements for energy and atmosphere in Turkey," 10th Int. Cong Advances in Civil Engineering, METU, Faculty of Engineering, Oct. 17-19, Ankara, Turkey, 2012
[13] R. Komurlu, D. Arditi, A.P. Gurgun, "Applicability of LEED's energy and atmosphere category in three developing countries Energy and Buildings," 84 (2014) 690-697.
[14] Szydlik, C. C., (2014) " Identifying and Overcoming the Barriers to Sustainable Construction," Doctor of Philosophy in Engineering Management, Faculty of the Graduate School, Missouri University of Science and Technology, USA.
[15] W. Peng and L. Sui Pheng, "Project Management and Green Buildings: Lessons from the Rating Systems," Journal of Professional Issues in Engineering Education & Practice, vol. 136, pp. 64-70, 2010.
[16] R. B. Handfield, S. A. Melnyk, R. J. Calantone, and S. Curkovic, "Integrating Environmental Concerns into the Design Process: The Gap between Theory and Practice," IEEE Transactions On Engineering Management EM, vol. 48, pp. 189- 208, 2001.
[17] K. R. Bunz, G. P. Henze, and D. K. Tiller, "Survey of Sustainable Building Design Practices in North America, Europe, and Asia," Journal of Architectural Engineering, vol. 12, pp. 33-62, 2006.
[18] Nerur, S., Mahapatra, R., Mangalaraj, G., 2005. Challenges of migrating to Agile methodologies. ACM Commun. 48 (5), 72–78.
[19] Soundararajan, S., Balci, O., Arthur, J., 2013. Assessing an organization's capability to effectively implement its selected Agile method(s): An objective, principles, strategies approach. In: Agile Conference (AGILE), 2013, pp. 22–31. doi:10.1109/AGILE .2013.9.
[20] Donmez, D., Grote, G., Brusoni, S., 2016. Routine interdependencies as a source of stability and flexibility. A study of Agile software development teams. In Information and Organization 26 (2016) 63–83.
[21] Agile Alliance. (2012, January 28). Manifesto for Agile Software Development
Available. Available: www.Agile manifesto.org
[22] Information Resources Management Association, 2012. Virtual Learning Environments: Concepts, Methodologies, Tools and Applications: Concepts, Methodologies, Tools and Applications.P.385.