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The Influence of Learning Styles on a Model of IoT-based Inclusive Education and Its Architecture

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Abstract

The Internet of Things (IoT) is a new paradigm that is revolutionizing computing. It is intended that all objects around us will be connected to the network, providing "anytime, anywhere" access to information. This study introduces IoT with Kolb's learning style in order to enhance the learning experience especially for inclusive education for primary and secondary schools where delivery of knowledge is not limited to physical, cognitive disabilities, human diversity with respect to ability, language, culture, gender, age and of other forms of human differences. The article also emphasizes the role of learning style as a discovery process that incorporates the characteristics of problem solving and learning. Kolb's Learning Style was chosen as it is widely used in research and in practical information systems applications. A consistent pattern of finding emerges by using a combination of Kolb's learning style and internet of things where specific individual differences, learning approach differences and IoT application differences are taken as a main research framework. Further several suggestions were made by using this combination to IoT architecture and smart environment of internet of things. Based on these suggestions, future research directions are proposed.

Keywords : Internet of Things, Learning Styles, Kolb, Inclusive Education

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1. Introduction

The 21^{st} century students build confidence in managing their own learning, learn by doing connecting the classroom to the larger world, thrive in positive school cultures where they are engaged and motivated to excel, develop an understanding of global challenges and a commitment to act as responsible citizens. Learning demands new pedagogical and technological approaches to using technology [Mcrae et al., 2018]. It is the responsibility of all educators to prepare students for the demands of an ever-changing world, through facilitating learning in a technology-rich environment, where students and teachers don't just learn about technology, they use it to achieve powerful teaching and learning by improving student learning expectations.

Nowadays students use mostly Google applications as a main educational resource, they create accounts and are introduced to Google Drive, Google Classroom, and other Google services. Along with Google Drive, students improve their tech skills by learning how to create animations, presentations, podcasts and narrations that show what they have learned and researched. They also use many browser-based learning environments to experiment and develop projects for their Units of Inquiry. Students are able to undertake deep research on the web using big data and are able to shift through that data to design and present very in-depth projects. They learn how to design websites, student portfolios and learn basic programming. They learn how to manage their time on and offline while using technology.

Technology should meet all environmental, social justice, and academic goals. Nowadays each student must know how to work with smartphones, tablets and laptops and utilize online instructional modules to become more proficient at keyboarding and familiar with the devices and applications [Rytivaara, 2012].

Schools today focus on student-centered needs that enable them to employ technological resources to enhance and advance their educational experience [Maenpaa et al., 2017]. The goal of the educational technology program is to promote the ethical and responsible use and strengthen the teacher-student relationship by building higher-order thinking skills, as well as technology literacy skills, to maximize the uses of technology for authentic purposes. Educational Technology shall enhance achievement and will be incorporated in all disciplines. Usage of technology will help teachers implement a universal design for learning which aims to provide equal opportunities to learn. Technology will allow teachers to "present information and content in different ways" (what), "differentiate the ways that students can express what they know" (how), and "stimulate interest and motivation for learning" (why) [Hollier et al., 2017]. This creates an active, engaged learning atmosphere in the classroom.

On our study we focus on the Internet of Things in inclusive education from Kolb's learning theory perspective. Next section of the article presents the Internet of Things and the architecture of IoT. Further inclusive education with the internet of things is also discussed where we discuss IoT in smart environment from the student perspective, classroom perspective and campus perspective. Then the article describes the importance of learning theories and Kolb's Learning Style, which is more practical in IoT applications and best describes the learning process in research and development teams. Finally, we combine and find commons in Kolb's Learning Style with internet of things and suggest individual characteristics in IoT architecture according to Kolb's Theory.

2. Internet of Things

The Internet of Things (IoT) is a new paradigm that is revolutionizing computing. It is intended that all objects around us will be connected to the network, providing "anytime, anywhere" access to information [Dutton, 2005]. Although IoT brings significant advantages over traditional communicational technologies for ubiquitous learning, these implementations are still not much used. Therefore, this study introduces powerful possibilities opened by the IoT which are being included to education system in order to enhance the learning experience for primary and secondary schools.

The IoT has been gaining space, thanks to advances in telecommunications such as the expansion of broad bands, the new IP protocol version 6 and nanotechnology integrated into countless electronic devices, ranging from mobile devices, vehicles, appliances and more [Sheng et al., 2015]. The idea of the Internet of Objects is to integrate all these devices into the network, which can be managed from the web and in turn, provide information in real time and also allowing the interaction with people who use it. Education, as any human activity nowadays, has not been immune to this phenomenon dating the e-learning, m-learning.

The potential of ubiquitous learning is reflected in increasing access to learning content and collaborative learning environments supported by computers anytime, and anywhere [Verma and Sood, 2018]. It also allows the right combination of virtual and physical spaces. The purpose of ubiquitous computing technology by using IoT is improving learning processes. It is trying to adapt learning resources to different contexts of use of learners. Being in this area where the internet of objects plays an important role in learning processes in formal and informal education. Increasing demand for education and fundamental changes in the technology landscape require new approaches to computer science education.

Traditionally, the teaching of embedded systems programming, sensor networks, and similar topics is deferred to higher-level courses, while introductory courses focus either on more fundamental topics or computing technologies that are "closer to home", such as PCs and Web programming [Domingo, 2012]. In contrast IoT based education focuses on current technologies and will be essential for the foreseeable future. Even though the concept is not well-defined, it is both possible and necessary to incorporate the IoT early on in education system because it orients students toward the future of computing and society.

Additionally, the physical computing aspects draw in students who, according to direct testimony from students and public discussions on forums such as Facebook or SNS, would never have considered a traditional computer science course. Even though there is tremendous excitement about online education, most course offerings are limited to subjects that can easily be taught online. For computer science, this means that courses focus on topics that can be studied with commodity technology, such as desktops and laptops. It is time to investigate large-scale and scalable online teaching infrastructures for computer science education, ranging from cloud computing to the IoT. It is often difficult for individual universities to develop the infrastructure in-house.

Developing IoT based courses requires a multi year effort by a large group of dedicated educators and a significant investment in people and technology. The IoT is seen as the next revolution in IT [Bagheri and Movahed, 2017]. Emerging originally out of a learning context, the IoT is still primarily associated with the interests of large educators. However, unless we willfully expand the discussion and assign the needs, desires, and fears of ordinary learners as much importance as the requirements of educators, there is the danger that the IoT will fall short of its potential.

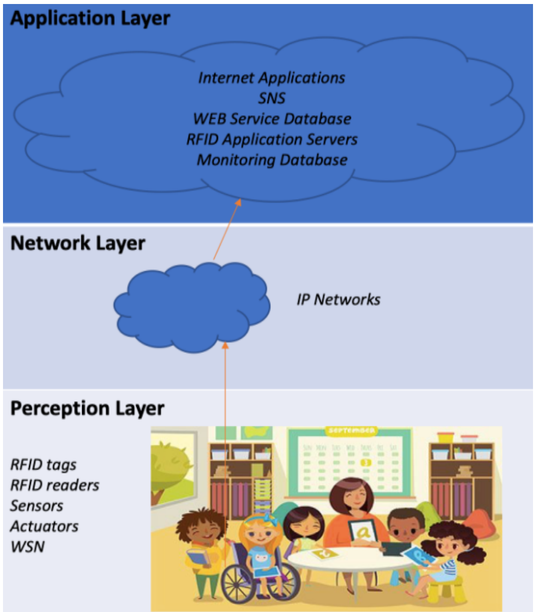
3. IoT Components

The Internet of things still has challenges that are inherent in its three layers as shown in ⟨Figure 1⟩.

- First level: Hardware layer, that allows the interconnection of physical objects through sensors and related technologies. The challenges associated to this layer are related to miniaturization. Internal components should be smaller and more efficient, although today they are equipped with devices with processing, storage and connectivity capability. Capacities that might be expected to be increased in the near future.
- Second level: The network layer, which is currently with 4G networks. The great challenge is to connect billions of devices on a wireless network, being necessary the expansion of bandwidth and the electromagnetic spectrum. As telecommunications infrastructure is currently not suffice to support the inclusion of a large number of electronic devices, it is a challenge that has to be solved as soon as possible.
- Third level: Applications layer, which is plenty of opportunities to offer solutions to supply and provide information, from the physical to the virtual objects, as well as the interaction with people, making life easier and more efficient all the time.

RFID is a wireless technology that allows for automated remote identification of objects. An RFID system uses wireless radio communication technology to uniquely identify tagged objects or people. Today, RFID is applied widely in supply-chain tracking, retail stock management, parking access control, library book tracking, marathon races, airline luggage tracking, electronic security keys, toll collection, theft prevention, and healthcare. The major components of an RFID system are tags or transponders has a unique identification number (ID) and memory that stores additional data such as manufacturer name, product type, and environmental factors including temperature, humidity, and so on, that are affixed to objects of interest and readers or interrogators that communicate remotely with the tags through wireless communication to enable identification [Chew et al., 2015].

The Wireless Sensor Networks comprise of relatively inexpensive sensor nodes capable of collecting, processing, storing and transferring information from one node to another that can be deployed on the ground, in the air, in vehicles, inside buildings, or even on human bodies. Sensor networks are the key to gathering the information needed by smart environments, whether in buildings, utilities, industrial, home, shipboard, transportation systems automation, or elsewhere. Sensor networks are employed in environment monitoring, biomedical observation, surveillance, security, and other applications [Sheng et al., 2015]. Sensors in wireless sensor networks (WSNs) sense the environment and forward data to a sink. A sink node aggregates some or all the information that usually is far away from the data source. Sensor energy cannot provide long range communication to reach the sink due to the limited energy of sensor, hence multi-hop wireless connectivity is required to forward data to and from remote sinks. Each of the distributed sensor nodes has the capability to collect data, process them, and route them to sink node. Router nodes are deployed in sensor field to forward data from sensor nodes to remote sink node.



〈Figure 1〉 IoT Architecture

4. IoT-based Inclusive Learning

Inclusive education refers to the model where the schools'structure covers all children learning together in spite of their language, culture, gender, age, physical or cognitive disabilities and other forms of human differences [Ainscow, 2005]. Inclusion rejects the notion of schools or classrooms for special children which separate students with disabilities from students without disabilities. For these reasons, the need for IoT based solutions will be incontestable. It is expected that smart objects will be dominant on the market in the next few years and will become ubiquitous in learning environment, which will impose the need for new and improved services for smart education system.

There are several IoT technologies as essential for building successful IoT solutions: radio frequency identification (RFID), wireless sensor networks (WSN), middleware, cloud computing and software for application development [Gubbi et al., 2013]. They also identify three IoT categories for enterprise applications: monitoring and control, big data and business analytics, and information sharing and collaboration which are very necessary for inclusive learning. All data from different sources is accumulated in the cloud.

Environments can foster the participation and inclusion of disabled individuals in social, economic, political and cultural life. The IoT creates enabling environments by offering people with disabilities assistance in building access, transportation, information and communication. Sensory or mentally handicapped children can use interactive play and learning IoT environments to experience a richer learning experience, have more opportunities for language acquisition, become better at interacting with others and thus obtain higher self-esteem. In addition, these interactive IoT systems adapt to their learning rhythm. For instance, deaf children often need additional exposure to the American Sign Language because most on their parents are hearing and not fluent in this language. Now they can take this interactive IoT system with them from school to home and repeat the most difficult vocabulary until they understand and memorize it [Domingo, 2012].

5. IoT-based Smart Environment

To perform routine tasks there will be smart environment where all tasks are performed by smart devices is Mark Weiser's idea [Weiser, 1991]. Therefore, the main purpose of IoT-based technology is to provide easy access in everyday routine. If we talk about smart city for example, when we drive cars, we want to know about the road conditions, best route, traffic jams or want to change the radio stations, etc. By using sensors, actuators and smart devices, anyone can get any information only by his voice [Husnjak et al., 2014]. Creative environments must learn or understand how the environment works and thinks and must able to react according to the action or situation. A smart environment can be expressed "as one that can acquire and apply knowledge about the environment and its inhabitants to improve their experience in that environment" [Youngblood et al., 2005].

5.1 Student Perspective IoT

We all know that it is not that easy to take attendance of each student and it is a time-consuming task. Use of IoT can save time and effort both by smart attendance system. A study proposed an efficient smart classroom roll caller system (SCRCS) using IoT architecture to collect or record student attendance after every period accurately and timely. RFID tags are attached to the Students' ID cards. The SCRCS can be installed in every classroom and read the students' identity card collectively. It shows not only the total attendance e on LED display at the beginning of any class but also shows the all identity card on multiple slots of SCRCS. The record of a student's attendance is also kept at the academic office[Chang, 2011]. Another study proposed a web-based attendance system using NFC technology in Android smart phones. The student taps the matric card towards the NFC Android Smartphone, and the attendance will be saved on the server automatically. Teachers and students both can check the presence from their smart phones [Alghamdi and Shetty, 2016]. Real-Time Feedback on Lecture Quality: Students' understanding directly relates to the lecture quality. Students' feedback plays an essential role to improve lecture quality. A study proposes a creative environment that can monitor and observe students' reactions to a lecture using sensing and monitoring technology. This IoT-based smart device provides real-time feedback on lecture quality which will help to improve the lecture quality [Chew et al., 2015].

5.2 Smart Classroom Perspective IoT

Apart from student personal perspective of IoT, smart classrooms concept is very important. This concept means an intellectual environment equipped with advanced learning aids based on latest technology or smart things [Gul et al., 2017]. These smart things can be cameras, microphones and many other sensors, which can be used to measure student satisfaction regarding learning or many other related things. The smart object provides ease and comfort for class management. Use of IoT in a classroom may help to provide a better learning and teaching environment. Smart Classroom Management: The term "classroom management" means a way or approach a teacher uses to control his classroom. Smart devices have made it possible for a teacher to decide when he should speak louder when students are losing interest, or their concentration level is decreasing [Rytivaara, 2012]. The use of IoT devices for teaching and learning purposes is a hot trend among institutions across the world which provides a new and innovative approach to education and classroom management. Such tools are already being utilized. Some of the commonly used IoT devices in the classroom are: Interactive White boards, Tablets and Mobile devices, 3-D Printers, eBooks, Student ID Cards, Temperature Sensors, Security Cameras and Video, Room Temperature Sensors, Electric Lighting and Maintenance, Attendance Tracking Systems, Wireless door locks [Gul et al., 2017]. Smart classrooms allow teachers to know what students want to learn and the way they want to learn which is beneficial both for faculty and students. Moreover, smart classrooms help students to understand the real purpose of using technology which also makes the learning process easier [Chang, 2011]. The advancement in the field of technology in education has facilitated educators to design classrooms which are productive, useful, and collaborative and managed through IoT.

5.3 Smart Campus Perspective IoT

Nowadays almost all university campuses are connected to the Internet, and on each campus there are multiple objects like windows, doors, projectors, printers, classrooms, labs, parking, and building, etc. Using sensors, RFID, NFC, QR tags and such other IoT technologies, these objects can be converted to Smart objects [CaţĂA, 2015]. A Smart Campus can be a collection of multiple smart things in a single system. An intelligent campus may include following: smart E-learning Application with IoT, IoT Sensors for Notes Sharing, IoT Sensors for Mobiles Devices, IoT-enabled Hotspot for Campus [Veeramanickam and Mohanapriya, 2016]. A smart campus may have many other smart features like smart parking, smart inventory, smart lighting, and smart tracking of students, goods and equipment using RFID technology. The smart education institute has smart classrooms, smart corridors with info boards and data centers for processing all types of data [Simić et al., 2015].

6. Learning Styles

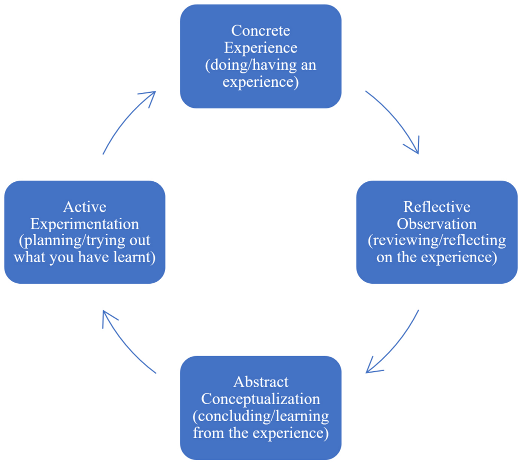
Individual learning styles differ, and these individual differences become even more important in the area of education [Säljö, 1981]. Therefore, the real challenge inIoT is keeping the people it is designed for in mind. Learning style is defined as an individual's inherited foundation, particular past life experience and the demands of the present environment that emphasize some learning abilities over others. Educators should be aware of how people obtain and preserve skills and how they access information to help their progress. Some scholars indicate that a primary goal in studying a new medium of communication for educational delivery must be the identification of its impact on learning. Students may benefit from understanding their own learning style by taking measures to adjust the way they acquire knowledge.

While instructors cannot always accommodate each student's need, it is important that several learning opportunities are provided. It is expected that when the learning experience is more effective for the student, an increased level of user acceptance of information systems will result. Researchers believe that learning style is a good predictor of an individual's preferred learning behavior. There was found that a match between learning style and teaching style reveals increases in student achievement and satisfaction. Contrary to these finding, there is no significant relationship between the information-processing characteristics of learning style and performance. In addition, no significant interaction among the factors of learning style, hypermedia's organizational structure and attitude. Learning style does not significantly influence a subject's learning.

While there is plenty of study done on learning styles, there does not seem to be any agreement or approval of any one theory. Furthermore, not all researchers and writers agree with learning style models. A research report from the Learning and Skills Research Center studied many influential learning style models and did a critique of all experimental learning style theories. This research questions the reliability, validity and implication of learning styles in general. In addition, the authors have criticized some of the research that has used these models including the Kolb's learning style model and disagreed with the way they came to their conclusions. According to the paper, Kolb's Learning Style Inventory (KLSI) in general 'should not be used for individual selection'. Referring to the validity and reliability of KLSI the paper indicated that 'the construct validity of the KLSI has been challenged and there is a long public dispute over reliability of KLSI' [Kolb, 1985].

7. Kolb's Learning Style

David Kolb published his learning styles model in 1984 from which he developed his learning style inventory as shown in ⟨Figure 2⟩. Kolb's experiential learning theory works on two levels: a four-stage cycle of learning and four separate learning styles. Much of Kolb's theory is concerned with the learner's internal cognitive processes. Kolb states that learning involves the acquisition of abstract concepts that can be applied flexibly in a range of situations. In Kolb's theory, the impetus for the development of new concepts is provided by new experiences. "Learning is the process whereby knowledge is created through the transformation of experience" [Kolb, 1985].



⟨Figure 2⟩ Kolb Learning Style

1. Concrete Experience-(a new experience of situation is encountered, or a reinterpretation of existing experience).
2. Reflective Observation (of the new experience. Of particular importance are any inconsistencies between experience and understanding).
3. Abstract Conceptualization (Reflection gives rise to a new idea, or a modification of an existing abstract concept).
4. Active Experimentation (the learner applies them to the world around them to see what results).

Kolb's learning theory sets out fourdistinct learning styles, which are based on a four-stage learning cycle. Kolb explains that different people naturally prefer a certain single

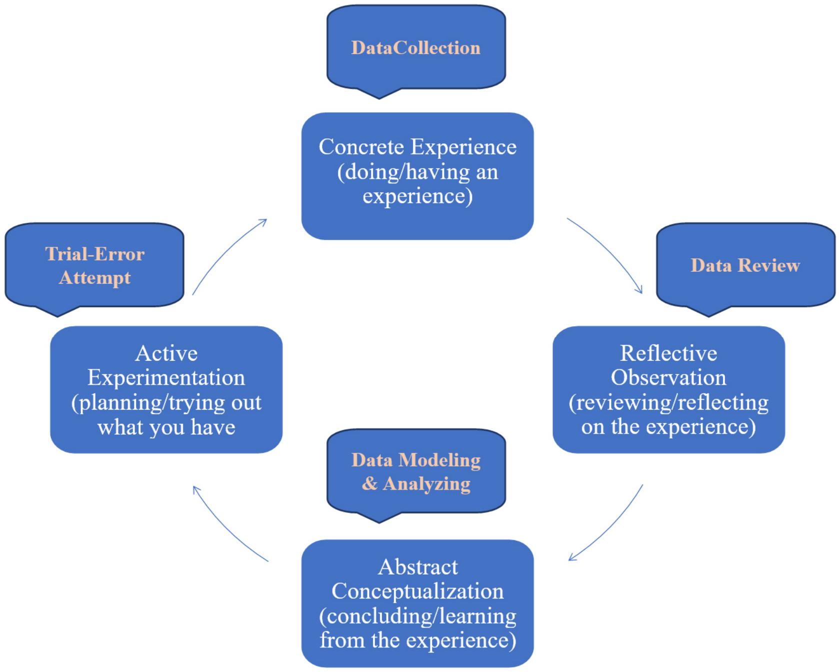
〈Table 1〉 Learning Styles Descriptions

	Doing (Active Experimentation-AE)	Watching (Reflective Observation-RO)
Feeling (Concrete Experience-CE)	Accommodating (CE/AE)	Diverging (CE/RO)
Thinking (Abstract Conceptualization-AC)	Converging (AC/AE)	Assimilating (AC/RO)

different learning style [Kolb and Kolb, 2013].

Various factors influence a person's preferred style. For example, social environment, educational experiences, or the basic cognitive structure of the individual. Whatever influences the choice of style, the learning style preference itself is actually the product of two pairs of variables, or two separate 'choices' that we make, which Kolb presented as lines of axis, each with 'conflicting' modes at either end:

A typical presentation of Kolb's two continuums is that the east-west axis is called the Processing Continuum (how we approach a task), and the north-south axis is called the Perception Continuum (our emotional response, or how we think or feel about it). Kolb believed that we cannot perform both variables on a single axis at the same time (e.g. think and feel). Our learning style is a product of these two choice decisions. It's often easier to see the construction of Kolb's learning styles in terms of a two-by-two matrix as shown in 〈Table 1〉. Each learning style represents a combination of two preferred styles. The diagram also highlights Kolb's terminology for the four learning styles: diverging, assimilating, and converging, accommodating:



〈Figure 3〉 IoT & Kolb's Learning Style

〈Table 2〉 Kolb and IoT Architecture

APPLICATION TO STYLE	PERSPECTIVE LAYER	NETWORK LAYER	APPLICATION LAYER	STUDENT PERSPECTIVE IOT	CLASS PERSPECTIVE IOT	SCHOOL PERSPECTIVE IOT
ACCOMODATING	25%	15%	60%			
DIVERGING	40%	10%	50%	Smart bands; smart id cards	Temperature Sensors; Attendance tracking systems;	Environmental Sensors; Smart school bus; Security Cameras
ASSIMILATING	50%	10%	40%	Diary making apps	Interactive displays; visual coding classes	
CONVERGING	40%	50%	10%		AI Robotics Coding Classses; 3D printers	

There are several visions of IoT from different perspectives. As shown in the 〈Figure 3〉 above, we can define a consistent pattern by using a combination of Kolb's learning style and data centric internet of things. Working with data in IoT is the same as effective learning when a person progresses through a cycle of four stages: of (1) Data Collection- having a concrete experience followed by (2) Data Review-observation of and reflection on that experience which leads to (3) Data Modeling & Analyzing-the formation of abstract concepts and generalizations which are then (4) Trial-Error Attempt-used to test hypothesis in future situations, resulting in new experiences. Kolb [1985] viewed learning as an integrated process with each stage being mutually supportive of and feeding into the next. It is important to follow the stage through its logical sequence and effective learning only occurs when a learner is able to execute all four stages of the model. Therefore, no one stage of the cycle is an effective as a learning procedure on its own.

According to our suggestion accommodators and divergers can perform better in application layer-60% and 50%, whereas convergers and assimilators in network layer -50% and perspective layer -50% respectively as shown in 〈Table 2〉. According to researchers marketing managers are found to be accommodators and engineers tend to be more convergers [Kolb and Fry, 1975].

8. Conclusion

In this article we displayed the importance of learning style in learning the internet of things and suggested that the same approach may not be suitable for new learners especially in inclusive education. Beginners should consider the way of accommodating according to individual needs. Therefore, some guidelines were suggested in this article. For example, accommodators and divergers can perform better in application layer, whereas convergers and assimilators in network and perspective layers respectively. For software programmers, it is recommended to consider individual's differences which influences on their perceptions, therefore, we suggested that Kolb's learning theory is more practical in IoT applications and best describes the learning process in research and development teams. Moreover, we suggested that the educational environment in inclusive learning should be considered as student, class and campus perspectives of IoT separately, and all the IoT technology and applications, the students will use, should be considered to individual needs. For the future research, it is important to consider the individual difference variables with internet of things' architecture and measure with the method of Kolb's learning style inventory. In order to increase the number of learners and effective users of internet of things, much more investigation is needed to perform. The authors of research tried to make the first attempt toward learning IoT with different individuals by Kolb's theory and they hope that suggestions presented in this study will inspire other researchers to continue efforts in this direction.

With a beginning of Industry 4.0, the Internet of Things has become a driving force and expanding area of research and business. Many efforts from researchers, vendors and governments have been devoted to creating and developing new IoT applications. Along with the current research efforts, we support more insights into the problems of this promising technology, and more efforts in investigating nowadays' research issues.

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