IOT IN REINFORCEMENT LEARNING

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ABSTRACT
Learning has become an integral part of life. This paper tries to find out how IoT enabled devices can be used to improve the reinforcement learning process for the betterment of the learners. This article is based upon secondary data sources as well as discussions with the experts in the field of learning and IoT enabled devices. IoT can contribute to designing effective simulations, assignments, and video-based learning for the learners. It will also help the training and development department to create an effective learning environment with the help of trainers for the learners. The third contribution of IoT enabled devices will be in conducting formative and summative performance evaluation of the learners as well as their behavior. It is also beneficial for bringing accuracy in case of handing over reward or punishment to the learners based on their performance. IoT enabled devices are contributing significantly to improve the outcome of reinforcement learning for the learner, trainer, and organization at large. The future of learning is not dependent on experiential learning through IoT. Pandemic has accelerated the use of IoT based learning.
Keywords:IoT, Deep learning, Reinforcement learning, Learning process, IoT enabled devices

Introduction

Learning is a process by which permanent change occurs in learning. Learning process has been studied for the last so many years to find out how effective learning can be achieved for the development of the learner. Psychologists started doing more research on this concept from the early part of the 20th century. The outcome of their study was the emergence of different behavioral theories. These behavioral theories are based upon the impact of environmental influences on the process of learning. The term environmental influence is incorporated with reinforcements, associations, and punishments.

Ivan Pavlov, a famous Russian psychologist, in his theory paired the natural stimulus (food) with the sound of a bell. The response of the dog to this situation was the generation of saliva in his mouth. But because of multiple associations developed by Pavlov the dog started salivating even to the sound of the bell. He proved that learning occurs by forming effective associations between various stimuli (naturally occurring and previously neutral).

B. F. Skinner, a behavioral psychologist, explained the process of learning by creating associative learning which is done through behavioral modifications with the help of reinforcement. Learning can take place effectively when behavior is followed by its consequences.
Cognitive learning theories are more focused on the following things.
    a. Attention span.
    b. Memory
    c. Information processing

All the above factors in the case of a learner decide the level of acquisition of knowledge. Piaget explained the intellectual development process that occurs in childhood in four stages

Stage No.	Name of the stage	Type of development
1	Sensorimotor stage	Cognitive development by learning about the world through the senses of a learner.
2	Preoperational stage	Learning about language through pretend play
3	Concrete operations stage	Utilization of logic by the learner.
4	Formal operations stage	Use of deductive reasoning by the learner. Developing understanding about abstract and hypothetical ideas by the learner.

Table No. 1: Stages of Intellectual Development
ProcessSource:https://www.techtarget.com/searchenterpriseai/definition/reinforcement-learning

Constructivist learning theories are based on the approach of learners' participation in the process of learning will be for constructing their knowledge. Lave Vygotsky, a psychologist in this regard, proposed two important concepts for constructivist learning. They are as follows.
1. More knowledgeable others – an individual whose understanding level is higher than a learner e.g., trainer, teacher etc.
2. Zone of proximal development – it is described as an ability displayed by the learner with the help of more knowledgeable others. But learners are not able to perform independently.

Literature Review
Albert Bandura believed that most of the learning in the case of learners will be done through observations. He also concluded that learning something will not necessarily result in a change in the behavior of the learner.

In experiential learning the process is based upon providing firsthand experience to the learners. Psychologist Devid Kolb explained the four stages in experiential learning. They are as follows.
a. Abstract conceptualization
b. Concrete experience
c. Active experimentation
d. Reflective observations.

Reinforcement learning is nothing but the ability of learning the association between stimuli, actions and getting rewards or punishment. The reinforcement process majorly focuses on strengthening the above-mentioned association. The reinforcer for this purpose will be reward (positive) and punishments (negative) reinforcers. Learners' behavior will be affected by these associations. If the learner demonstrates positive behavior, he / she will get a reward. If the learner demonstrates negative behavior, he/she will get the punishment. In this way reinforcers guide, inspire and motivate learners to learn effectively. (Bzai,2022)

The Internet of Things (IoT) is nothing but a network of things (physical objects) that are embedded with software, sensors, and different technologies with an objective to get connected and to exchange data with other systems or devices by using the internet.

Rajeshwari (2020) has explained about the application of IoT to access cognitive skills of learners. IoT is an interrelated system of digital / mechanical machinery and computer equipment. It is capable of transferring and relocating data without teacher to learner involvement or human to computer interactions over the internet. IoT applications involve multiple domains like Smart Cities, Smart Farms, better healthcare, Smart Transportation system, Smart grid, and Smart teaching learning process and so on.

Cognitive skills contribute to developing the mental capabilities of a learner. IoT enabled learning allows the learner to observe, perform and practice the topic or unit with the help of a trainer and their peers. It improves the effectiveness of learning. (Jones,2003)

Khaleel (2018) discussed enhanced learning management systems with IoT applications in their research work. Learning management system is a tool which contributes to creating, distributing, and managing diverse types of training material. It also does the tracking of the same. The researchers have provided a framework for enhancement of LMS by using IoT capabilities.

Lei, (2020) talked about autonomous IoT which is an integration of IoT and Autonomous Controlled System (ACS). They have introduced a concept of intelligent agent to control, reinforce, and learn and deep reinforcement learning.

As per the report of the Oracle today more than ten billion population is connected to IoT devices as experts are forecasting that this number will reach twenty-two billion by 2025. (Rahmani ,2021)

By using IoT connected devices effective communication is possible between people and things or processes and things. Sensors play a vital role in IoT technologies which are now available at low cost. (Mershad ,2018; Shammar, 2019). Connectivity, cloud computing platforms, machine learning and analytics, conversational AI are contributing to the IoT process. IoT is now used for many industrial applications by different organizations. About industrial IoT, people feel that it is contributing to the fourth wave of industrial revolution which is called industry 4.0. Industrial IoT is used for the following processes.

a. Smart manufacturing
b. Connected logistics.
c. Smart digital supply chains
d. Smart power grids
e. Connected assets.
f. Preventive and predictive maintenance

IoT is making changes in the field of training and education. IoT connected tools and their usage in the process of teaching learning has sharply increased during and after Covid pandemic. (Jones,2003). Tablets and smartphones in the digital learning environment are being utilized by learners of all age groups. Graphics, augmented reality etc. are significantly contributing to explaining complex processes by making it simpler for learners. Learning platforms are contributing to the learning process with the help of pre recorded sessions, live classes,and simulations. All these can be utilized by the learner as per his convenience and learning ability. IoT can be a bridge between the learner and learning platforms. This article focuses on how IoT can be used to enhance the effectiveness of reinforcement learning. (Razzaque, 2019;Sayassatov, 2019).

Objectives of the study
1. To understand the mechanism of reinforcement learning in the context of the organizational training process.
2. To find out how IoT can be used for reinforcement learning.

Research Methodology
This research is based on secondary data which are collected from various books, research papers, articles, and online resources. Following are the statistics of the same.

Sr. No	Resource	Number
1	Books	04
2	Research Papers	18
3	Articles	07
4	Online resources	04

Table No. 2: Description of Secondary data Resources
Data was analyzed by keeping focus on how IoT can be used for reinforcement learning.

Secondary Data Analysis
The discussion is focused on two important aspects, one aspect is covering reinforcement learning and other aspects through light on the contribution of IoT in reinforcement learning. Reinforcement learning is part of the training process conducted in various organizations. This method is based on appreciating desired behavior required to perform a task and punishing undesired behavior that will not give expected results. In other words, in reinforcement learning, learners do or perform the following activities.
1. Able to perceive and interpret learning environments.
2. Will take appropriate actions.
3. Learning through trial-and-error methods.

Fig No. 1 : Reinforcement learning
https://www.synopsys.com/ai/what-is-reinforcement-learning.html

The above figure shows the process of reinforcement learning where learning outcomes in a given environment are tagged with reward policy.

Advantages of reinforcement learning are as follows:
   a. It does not need large datasets or branded datasets so that it is not a costly method.
   b. Reinforcement learning is a more goal oriented process so we can utilize the same for those tasks which are having properly defined goals.
   c. Reinforcement learning is a value based process which improves quality and quantity of the output.
   d. As reinforcement learning requires a specific environment which helps in providing multiple opportunities for learners of learning as per their pace.

Learning outcomes in case of reinforcement learning are as follows:
   a. Optimal policy: Maximize the expected learning outcome by connecting it with reward function and the state and action spaces of the environment.
   b. Exploration: Exploring the possibility of providing additional knowledge and skills to the learner.

Learning outcomes in case of reinforcement learning should be finalized by considering optimal policy principal and exploration policy principal.

Sr. No	Learning outcomes	Performance Indicator	Skill imbibed
1	Other than Expected	Learners perform different activities independently	Over skilled
2	Expected (Goal)	Learner performs independently	Fully skilled
3	Moderate	Learner performs but with the help of trainer	Moderate level

Table No.3 : Learning Outcomes
IoT can contribute in the following ways in case of making reinforcement learning more effective.

1. **Designing assignments or simulations**:
   In case of reinforcement learning, the learner is exposed to various simulations, assignments, or video-based learning. With the help of IoT we can design the above-mentioned tools (simulation, case study, assignment) in the following ways.
   a. Detailed explanation about the process which will guide the learner to perform each step independently.
   b. Rewards explanation about expected outcome and desired behavior for each of the steps in the process of that activity.
   c. In detailed explanation about reward and punishment policy.
   d. A brief about how performance will be measured, and behavior will be evaluated of the trainees.
   This will enable the learner to know each and everything about the activity which he or she is supposed to perform, outcome expected, evaluation criteria and reward/ punishment policies.

2. **Creating an effective learning environment**:
    Learning environment is one of the most significant factors in achieving a stage of effective learning. IoT based devices like cameras and sensor enabled devices for activities will help trainers to identify the difficulties faced by the learner. As the trainer in the initial stage will be in position to identify difficulties faced by the learner, the trainer will make necessary arrangements for the learner to overcome these difficulties. This will boost the confidence of the learner and will energize the learner to learn with more dedication.

Learning environment consists of many vital elements as follows:
    a. Facilities present at learning site: Facilities at learning site comprises seating arrangement, technical facilities, light arrangements and other infrastructural facilities. If the duration of training sessions or learning sessions are more all these facilities will be required by the learner. If these facilities are up to the mark the learners will enjoy the learning environment which will boast the learner. But if these facilities are not up to the mark, the learner will get irritated which will result in concentration lapses in learning.
    b. Quality of trainers is one of the most significant factors in the learning process. Ability of the trainer to use the learning environment to its optimum will increase the interest of the learner. If the interest of the learner is high, effective learning can take place. So a trainer should use the available facilities in the learning environment for the process of learning.
    c. Adequate facilities for practice sessions should be available in a learning environment for the learners. More practice sessions under the supervision of a trainer / instructor will help learners to acquire required space and competencies by getting more opportunities for improvement in performance.

3. **Evaluation and reward:**
    As the performance of the learner in reinforcement learning by using IoT enabled devices will be monitored continuously. The activities where learning is taking more time or unable to perform will be identified and more practical sessions can be given to overcome this problem. This formative type of evaluation will improve knowledge, skills and competency level of the learner and will perform the assigned task in such a way that expected outcome with behavior can be achieved. (Wuhui,2021).

As performance evaluation has been done effectively, appropriate reward or punishment decisions can be taken. This will make sure that no injustice will be done with each of the learners.

Transparent compensation and reward management practices will encourage learners to acquire more knowledge required for their job roles. It will minimize the time of learning and reduce the wastage which can be utilized for other activities.

IoT is contributing in all above mentioned levels. Apart from this it can be used for activities like tracking the movement of learners and trainers. It also helps us in analyzing learners' response to the trainer as well as the learning environment.
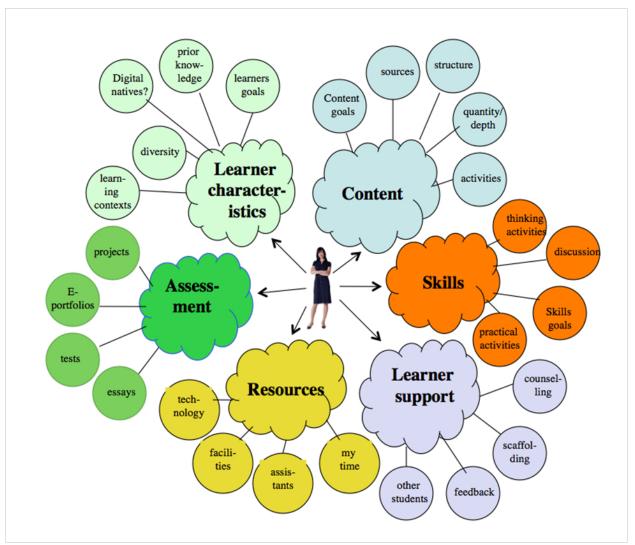
Fig.No.2 : Effective learning environment
Source : https://www.tonybates.ca/2016/02/22/building-an-effective-learning-environment/

The above figure clearly indicates to take care of six components in case of creating effective learning environment. They are characteristics of learner, content, skills, learner support, resources and assessment to get expected learning outcomes. organizations should invest in all above mentioned components.

Findings
1. Reinforcement learning can be used in organizational learning and development effectively for the trainees. Reinforcement learning delivers the results in the form of learning outcomes where other methods of training fail to deliver the same.
2. Reinforcement learning assures expected learning outcomes for learners as well as provides ample opportunities to acquire additional knowledge, skills and competencies for learners.
3. Outcome of reinforcement learning is associated with reward or punishment. This association motivates the learners to learn and perform effectively for an organization.
4. IoT contributes in improving the process of reinforcement learning by designing assignments or simulations, creating an effective learning environment and evaluation and reward.
5. IoT supports all three key elements in the process of reinforcement learning outcomes. It helps trainers to design the assignments and simulations as well as to monitor the progress of trainees. IoT also supports trainees to evaluate their learning and performance and IoT facilitates organization to check the process of learning as well as performance of the learners at each stage. This is benefiting all the three Key elements to rectify the things in a shorter duration of time if unfortunately somewhere the process gets derailed.

Conclusion

Learning is a process by which permanent change can take place in a learner by upgrading his/ her knowledge, skills, and competence levels. Reinforcement learning is one of the key processes in the entire setup of learning and development. Reinforcement learning assures expected learning outcomes with some additional outcomes for the learners. This process is associated with rewards and punishments which results in providing motivation for learners (trainees) for effective learning.

IoT enabled devices can be used effectively to design assignments and simulations which will help the learner to understand the task and practice the same. Another important contribution IoT devices will make in the reinforcement process is in creating an effective learning environment for the learners which will motivate them to learn and improve their competency levels. IoT based devices are also contributing to designing performance evaluation and reward management strategies for the learners.

Thus, IoT enabled reinforcement learning is proved as a boon for organizations, trainers as well as fast and slow learners (trainees).

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