Excellence in Digital Learning through Intelligent Technologies

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Abstract. Digital education is the innovative use of digital tools and technologies during teaching and learning, and is often referred to as Technology Enhanced Learning The technologies and practices that have developed over the last decade have been heralded as opportunities to transform both online and traditional education systems. For educational organizations, digital adoption can help institutions become more competitive. In the wake of the pandemic, people have begun to realize the far-reaching power of education-driven technology. Artificial intelligence (AI) has led to a generation of intelligent technologies in education. Artificial intelligence (AI) allows teachers to create content that suits their students best while ensuring personalized learning. AI has tremendous potential to help students achieve the goal of knowledge seeking by helping in streamlining the education process. AI could make significant and positive impact on students by providing access to the right courses, improving communication with teachers, self-assessing their skills and leveraging social tools for knowledge sharing with their peers. This research aims to present various facets of Digital Education and application of Intelligent Technologies to deliver and receive Digital Education in a professional manner.

Keywords: Digital Teaching and Learning, Intelligent Technologies, Artificial Intelligence (AI), Game Based Learning, Personalized Learning, Intelligent Tutoring System

1 Introduction

Digital Learning may be defined as technology facilitated learning to enable students to gain some element of control over time, place, path and pace [50]:-

- Time - Students may learn any time
- Place - Students may learn anywhere
- Path - Students may learn topics in any sequence
- Pace - Students may learn at their own speed and capability

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Artificial Intelligence; a complex blend of sciences such as cognitive sciences, psychology sciences, and mathematics sciences; has a great potential to resolve some educational challenges[6]. Some of the earliest efforts to embed AI into education resulted in building Intelligent Tutoring Systems, which aimed to tailor instruction to the individual needs of students [6]. Artificial intelligence (AI) systems may be used to support Digital Learning in multiple ways - by providing personalized learning, by helping to streamline teacher's tasks and by creating adaptive assessments etc.[40]. Previous Research has demonstrated that AI could be a student support tool in education; by supporting students who are concerned about their grades and workload; by suggesting study materials based on an analysis of students' quiz performance; by providing students with personalized exercise problems suited to their skills [40].

This research article presents the various facets of Digital Education and application of Intelligent Technologies to deliver and receive Digital Education in a professional manner. The remaining part of the paper is structured in the following sections:-

- Emergence of Digital Teaching
- Impact of COVID19 on Digital Learning
- Intelligent Technologies
- Gagne's Taxonomy
- Digital Literacy
- Advances in Intelligent Technologies for Digital Learning
- Effectiveness of Digital Teaching and Learning
- Conclusion.

2 Digital Education and Application of Intelligent Technologies

2.1 Emergence of Digital Teaching

Digital education is the innovative use of digital tools and technologies during teaching and learning, and is often referred to as Technology Enhanced Learning. In a digital learning setting, technology takes shape of a tool to aid learners to access information, to share information and collaborate with others [5]. Numerous technologies and tools have helped to implement and leverage digital learning. Cloud Computing based low cost of free services such as Massive Open Online Courses (MOOC), Google Aps, Open Education Resources (OER), Digital Learning Resources (DLR) can be used by Educational Institutes and Learners for various educational processes and knowledge transfers. Mobile Technologies have gained exponential growth and popularity in past years and most people in this world use at least one mobile technology based device for day-to-day needs. Mobile technology enables learners to download educational content, upload assignments and access knowledge resources at any time at any place due to the omnipresence of this technology. Game Based Learning is the application of gaming to learning by engaging students in educational games and entertaining formative assessments. Modern game based tools such as Kahoot, Quizizz, Schoology, Mindtickle etc. are quite easily available either as completely free versions or freemium versions.

Table 1. Technological Factors affecting Digital Teaching

Technology Factor	Examples of Factor on Digital Teaching	Citation
Cloud Computing	Cloud based services such as Massive Open Online Courses (MOOC), Google Aps, Open Education Resources (OER), Digital Learning Resources (DLR) etc.	[14], [5]
Mobile Technology	Mobile Technologies such as smart phones, tablets, laptops etc.	[14], [5], [43]
Game Based Learning	Game based assessment tools such as Kahoot, Quizizz, Schoology, Mindtickle etc.	[14], [5]

2.2 Impact of COVID19 on Digital Learning

COVID-19 is the disease caused by SARS-CoV-2, the coronavirus that emerged in December 2019. COVID-19 can be severe, and has caused millions of deaths around the world as well as lasting health problems in some who have survived the illness. The rapid spread of COVID-19 across the globe caused most countries to implement social distancing rules. The COVID-19 pandemic changed digital transformation as the Institutes and Schools worldwide had to shut doors to their campuses owing to the strict enforcement of lockdowns of diverse severity. In some countries, the military controlled streets and nobody was allowed to come out of homes barring emergencies. In other countries, they started issuing digital passes for few hours to enable people to buy urgent grocery needs and medicines. Owing to the closure of Educational Institutes owing to lockdowns induced by global pandemic COVID-19 all teaching became mediated by digital technologies [38]. Because of the pandemic, the face-to-face classes worldwide were moved to a digital learning environment, thus transitioning traditional teaching to digital teaching [4]. Schools and Universities had to change face-to-face teaching methods and move to digital teaching and learning using online tools. Most common online tools used by educational institutes across the world were Microsoft Teams, Zoom Cloud Meetings, Google Meet and Blackboard Collaborate Ultra etc.

In order to sustain the lockdowns, governments, organizations and Institutes worldwide tried to implement some urgent measures:-

- Greater investment and prioritization of technology [17]
- Paying attention to faculty and student experiences on technology [41]
- Inspiring a ‘spring-cleaning’ of technology to streamline investments [28]
- Increase in use of automation to improve the student experience and build contactless services [46]
- Viewing technology as a means to innovate and thrive [36]
- Greater investment in cybersecurity [47]

The emergency response from educational institutions during COVID19 crises to shift teaching and assessments online, involved adapting content which would have traditionally been taught face-to-face as blended learning or as fully distanced learning. These challenges tested the Institutes globally and those with well-thought-out investments in ICT over past decades emerged more successful.

2.3 Intelligent Technologies

Intelligent Technologies have a great potential to improve quality of Digital Learning quality. Artificial Intelligence (AI) has witnessed an exponential growth and its application in modern education has tremendous potential to effectively improve teachers' teaching ability with support of intelligent technology [34]. Artificial Intelligence (AI) promises a new way forward for educational processes such as assessments and performance measurability [8]. Intelligent technologies and tools such as advanced tutoring systems, smart data collection, adaptive learning, personalized learning, and intelligent feedback systems for learners etc. [20].

Artificial intelligence has led to a generation of intelligent technologies in education:-

- AI allows teachers to create content that suits their students best while ensuring personalized learning [25].
- AI automates tasks, so teachers have more time to do more teaching and impact the students better [31] [38]
- AI can help students learn better and faster when paired with high-quality learning materials and instruction [15] [23]
- AI systems can also help students get back on track faster by alerting teachers to problems the naked eye cannot see [21] [18]

2.4 Gagne's Taxonomy

Gagne's model of instructional design is based on the information-processing model of the mental events that occur when adults are presented with various stimuli and focuses on the learning outcomes and how to arrange specific instructional events to achieve those outcomes [11] [12]. Gagne suggests that learning tasks for intellectual skills can be organized in a hierarchy according to complexity: stimulus recognition, response generation, procedure following, use of terminology, discriminations, concept formation, rule application, and problem solving [11] [12].

Gagne's Taxonomy outlines nine instructional events and corresponding cognitive processes [11] [12]:-

- Event 1: Gaining Attention (Reception) - It is important to gain the attention of your audience at the beginning of a learning experience. It sets the stage for what is happening in the course.
- Event 2: Informing Learners of the Objective (Expectation) - The "what", the "how", and the "why" of the course need to be put forth early in the learning experience.
- Event 3: Stimulating Recall of Prior Learning (Retrieval) - All learning is provided in context with what the person knows or has learned so far.

- Event 4: Presenting the Stimulus (Selective Perception) - This is the part of the course where new information is presented, matching the learning objectives, as well as the knowledge and learning styles of the learners.
- Event 5: Providing Learning Guidance (Semantic Encoding) - Show students what appropriate actions constitute correct performances. Once the information is presented, it should be re-presented in a way that demonstrates its application to realistic situations.
- Event 6: Eliciting Performance (Responding) - At this stage of the learning process, learners are asked to demonstrate whether they understand the concepts presented and can apply the skills taught.
- Event 7: Providing Feedback (Reinforcement) - While observing each learner perform, individual and immediate feedback and guidance must be provided.
- Event 8: Assessing Performance (Retrieval) - This event includes comprehensive assessments of what was learned, and demonstration of the learner's ability to apply the knowledge gained to specific situations.
- Event 9: Enhancing Retention and Transfer (Generalization) - In this final stage, learners demonstrate that they can not only retain the information provided but also apply it in similar situations.

In his book "The Conditions of Learning" first published in 1965, Gagne outlined the above Nine Events of Instruction (also depicted in figure 1 below) and these nine events are widely used as a foundation upon which to structure an online course [9].

Fig. 1. Gagne's Nine Events of Instruction [9]

Gagne's Learning Theory includes signal learning, stimulus-response learning, verbal association and discrimination learning but it also discusses on cognitive activity during learning, which is considered an intermediary factor between stimulus and response and hence this theory is important from an information processing perspective [51]. Gagne's learning model and its nine levels of instruction have been engaged in communication among the learners leading to learner's retention of skills, enhancing the learning experience, fulfilling different types of learners' needs according to their learning styles and providing more learning opportunities [39]. Gagne's instructional design can support in usability, motivational characteristics, and the implementation of learning styles in digital learning [10]

2.5 Digital Literacy

Digital literacy may be described as the capability of teachers and learning providers to use digital resources and virtual learning platforms in the educational environment [29]. COVID19 pandemic and its aftereffects triggered an instant transitioning from traditional classroom to online classroom, and posed serious challenges to teachers' professional role, career satisfaction level, and digital literacy [29]. On the other side of the spectrum, a learner must be able to recognize when data is needed and the learner should have the ability to locate, evaluate, and use the information effectively; and this is description of the learner's digital literacy. During pre-COVID era, a learner had limited opportunities to participate in digital literacy practices in everyday life and that most of these involve social interaction with family and friends; however post COVID, the learners had little or no time to gain digital literacy skills to adapt to online classrooms [32].

Educational Institutes and Schools need to build adequate information technology (IT) infrastructure to support high quality content provision to strengthen digital literacy of learners as well as learning providers (teachers) [24]. Under the digital literacy umbrella, there are numerous interrelated skills that range from basic awareness and training, to highly sophisticated and more complex creative and critical literacies and outcomes. Teachers must not only cultivate these skills for their own use, but also become promoters of digital competencies in their students. The more teachers model these proficiencies in the online classroom, the more adept their learners will be at implementing these skills in their own lives.

Application of AI technology to education has potential to overhaul traditional education through innovative teaching ideas, self-updating instructional contents and inventive pedagogies and upgrade teachers' professional quality and teaching [30]. Intelligent Technologies have a great role to play in boosting the digital literacy for learners as well as teachers. In Thailand, chatbots, as a type of intelligent conversational agent were used to enhance digital literacy for the senior citizens by including in it the necessary learning media and service functions [44].

2.6 Advances in Intelligent Technologies for Digital Learning

Digital learning is effective implementation of technology to any type of learning or instructional practice and may encompass a wide spectrum of educational practices such as blended learning and virtual learning. In this section, we will be discussing a

number of intelligent tools and technologies that could be used to implement or supplement digital learning.

Enhancing digital literacy with an intelligent conversational agent

Intelligent conversational agents could take form of virtual assistants deployed via mobile applications; with an aim to facilitate, engage, and interact with students to provide optimal learning experiences. Chatbots may be used as intelligent conversational agent, so as to provide 24/7 support to students and possibly create engaging experiences for the students. Chatbots may be often embedded in online messaging applications such as WhatsApp to leverage power of the tool's natural language processing to simulate responsive dialogues in conversations with students through voice messaging and text messaging as per convenience.

AISSMS Institute of Information Technology in India have implemented an automatic response giving system, which will give a reply to the student's questions through the AISSMS chatbot [16]. The AISSMS chatbot uses of artificial intelligence and machine learning for responding to user queries [16].

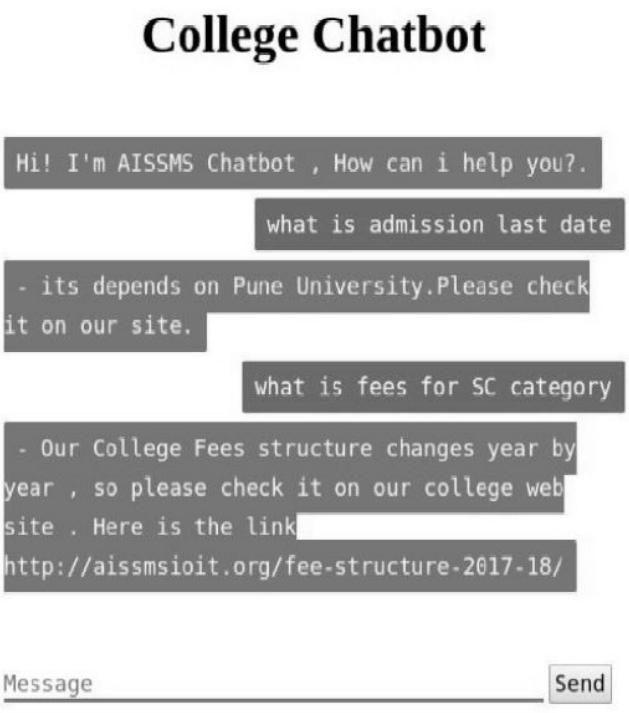

Fig. 2. AISSMS chatbot [16].

Siglo 21 a University in Spain, decided to use artificial intelligence solutions to respond to the new needs of its students. To do this, they implemented Aivo's conversational chatbot, powered by artificial intelligence [49] with following notable features:-

- The chatbot allows for self-service support, omnichannel experiences, and personalized answers.
- The virtual assistant also learns on its own as it interacts with the user. This developmental learning lets students receive immediate answers without help from a live person.
- Currently, the chatbot provides information on subject areas and their courses, exams, scholarships, registration, payment processing, help for accessing and using platforms, and contact information.

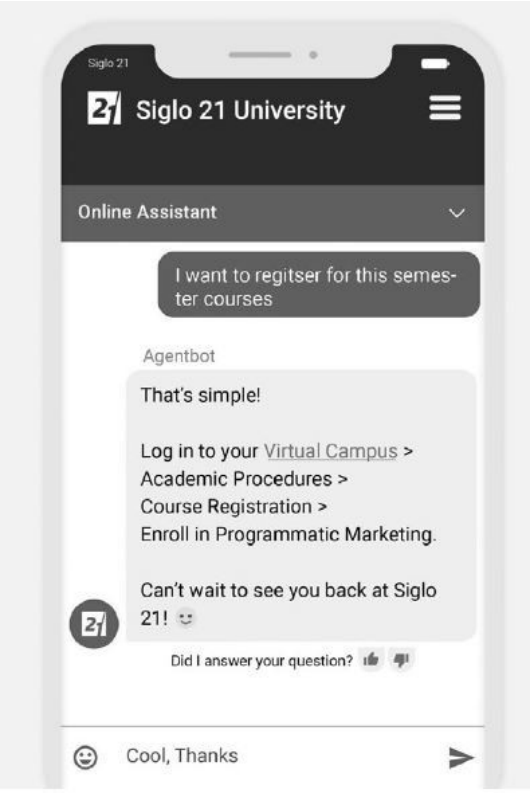

Fig. 3. Siglo 21 Aivo's conversational chatbot [1]

Siglo 21 University evaluates student-chatbot conversations regularly to monitors the level of student satisfaction thus helping them to ensure that their students can get immediate answers without human interactions [1]

Enhancing digital literacy with Personalized Learning

Personalized learning involves recognizing learner characteristics, needs, styles, and interests and offering a variety of activities and educational opportunities to make courses more individualized. This includes allowing multiple pathways to achieve course/module/topic goals, providing flexible pacing options, and developing performance-based assessments.

Personalized learning refers to a process which caters to students' strengths is an educational approach that aims to customize learning for building on each student's strengths and working on the student's weaknesses, through customized learning plans. With the power of AI, the teaching and learning process can be made 'intelligent' by enabling various by AI to achieve personalized learning path for each student [42].

Personalized Learning with AI-generated characters

Recent developments in artificial intelligence and machine learning has enabled possible hyper-realistic synthesis of prose, images, audio and video data to create artificial intelligence (AI)-generated characters which could possibly be used to supporting learning [33].

AI-generated characters can be defined as digital representations of a person created by machine learning algorithms that are made to look, sound and behave realistically and users can learn from an AI-generated character resembling an expert in a lecture for e.g. Albert Einstein as shown in Figure 4 below [33].

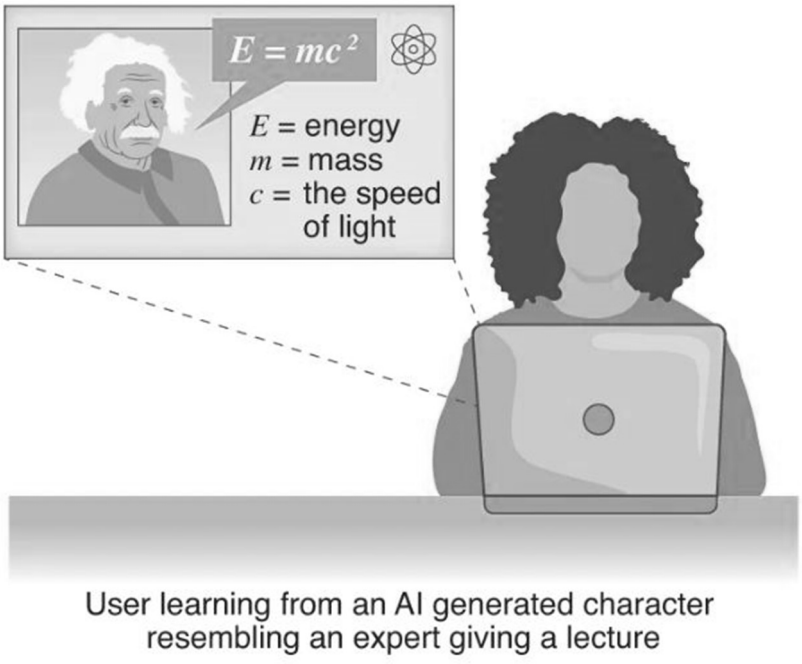

Fig. 4. AI-generated character to supporting personalized learning

Personalized Learning with Cloud Based AI Platform

University of Texas at San Antonio have successfully developed an educational AI powered cloud based called Cloud-eLab that enabled AI-thinking based learning and problem solving [37]. Cloud-eLab is an open and interactive cloud based learning platform for AI Thinking through Deep Learning; and Cognitive Adaptation of learning concepts for education [3]. Cloud-eLab education platform delivers personalized content for each student with flexibility to repeat the lessons and experiments at their own pace which allow the learner to be in control of the whole learning process [37].

As per the block diagram of Cloud-eLab shown below in Figure 3. Cloud-eLab; there are four main blocks [37] :-

- Access Control for ensuring security and privacy. The module helps to identify users and permits them to create and maintain their educational profile
- AI-Thinking clock provides for the deep learning process for cognitive learning and educational adaptation
- AI-Thinking block is augmented with computational thinking capability to support required level of thinking (and learning)
- Cloud computing block supports knowledge and data sharing, and access to computational resources and data storage.

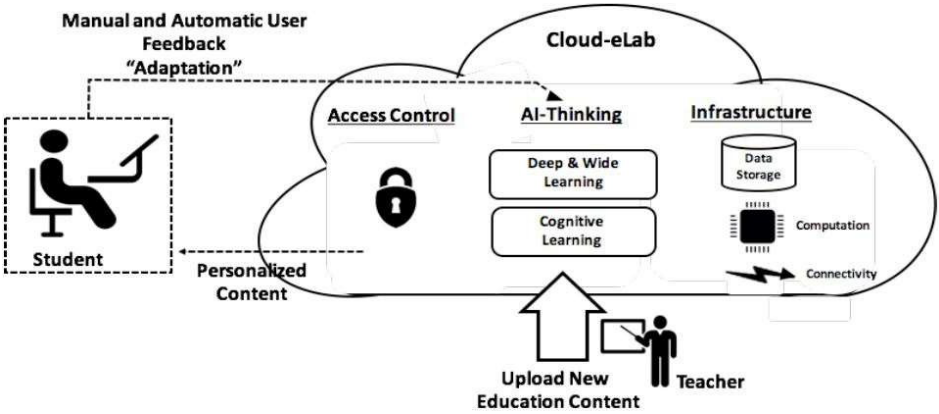

Fig. 5. Block Diagram of Cloud-eLab [37].

Digital Learning with Smart Rubrics

SmartRubric is an intelligent web app that uses interactive rubrics to capture rich formative assessment data after teachers mark assessments [45]. SmartRubric helps teachers mark open-ended student work such as projects, performances and essays quickly & accurately [22]. SmartRubric; a formative assessment app designed to ease teacher workload; is an end-to-end assessment system aimed to meet the needs of real teachers, students that can be used for any subject and at any level [2].

It captures granular formative assessment data and automatically creates clear, meaningful reports about individual, group or cohort progress against specific skills. SmartRubric application has a Login, Assessment, Rubrics, Classes, Students, and Admin functions [22].

Game-Based Learning

Game-Based Learning is an effort to leverage the potential of gaming principles and applying them to real-life settings to engage students to gain educational knowledge. The motivational psychology involved in game-based learning allows students to engage with educational materials in a playful and dynamic way [48]. Game-Based Learning is an effort to leverage the potential of gaming principles and applying them to real-life settings to engage students to gain educational knowledge. Game-based learning may have numerous benefits for students such as increased engagement in learning, better understanding of course content, enrichments in problem solving, and related academic accomplishments [13].

Well-designed educational games have tremendous potential to deliver high-quality learning, teaching students through gameplay the skills they need to complete the game, and related or aligned with educational content [7]. Quizizz, an online assessment tool was used extensively in school in Indonesia to teach English language skills to Class XII students and this experiment concluded that when implemented as gamified tool, Quizizz was capable of improving the learning process and motivating students [19]

PRIMARYAI game-based learning environment was designed to enable students to learn about AI as they address science problems with AI tools in the context of inquiry-based science adventures [27]. Designed to support small groups of students through problem-based learning cycles as they collaboratively engage with immersive life-science problem scenarios while gaining hands-on experience through exploration of AI-based methods, the structure of PRIMARYAI is shown in figure 6 below [27].

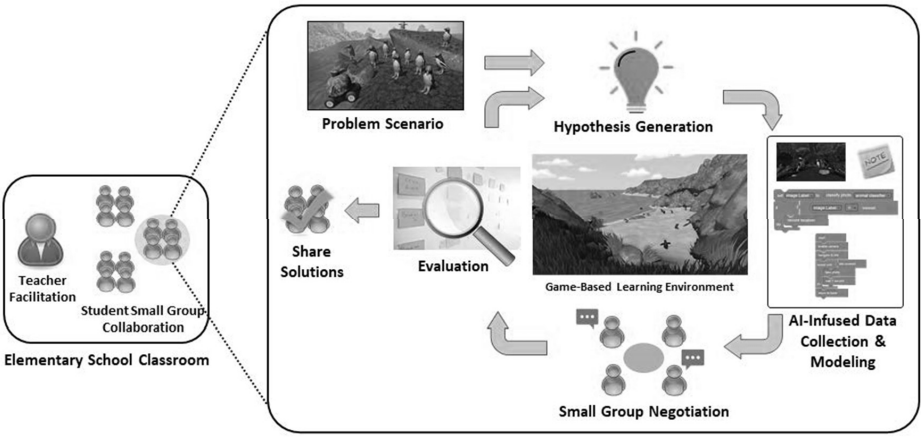

Fig. 6. PRIMARYAI game-based learning environment [27].

As shown in figure above, in the PRIMARYAI game-based learning environment, students will play the role of an ecologist who is investigating the recent declining population of yellow-eyed penguins on New Zealand's South Island [27].

2.7 Effectiveness of Digital Teaching and Learning

It has been said that you cannot manage what you do not measure, thus making evaluation an essential part of effective course design and meaningful digital teaching experiences. In order to evaluate the effectiveness of a digital learning initiative, we need to monitor factors such as students' learning motivation, learning ability, application of prior knowledge [53]. There can be two types of evaluation of digital learning initiatives - formative - to determine areas for improvement; and summative - to evaluate the outcomes [54]. Formative evaluation is an ongoing process that allows changes to be implemented during a course cycle. Summative evaluation occurs at the end of a course cycle and provides an overall description of course effectiveness.

Since 1959, Kirkpatrick's model has been used for the evaluation of training programs with its 4 levels of evaluation (reaction, learning, behaviour, results) which give answers to very important questions [55].

Figure 7 [56] below depicts the four levels of Kirkpatrick's Four Levels of Evaluation and these levels may be explained as follows [57]:-

- Level 1- Reaction – This level tries to gauge student's reaction during the course, whether students enjoyed it or whether they found it relevant. It may be possible to evaluate this level through verbal reactions, surveys, questionnaires etc.
- Level 2 – Learning – This level tries to gauge the knowledge and skills of the student. It may be possible to evaluate this level through questionnaires or tests etc.
- Level 3 – Impact – This level tries to gauge the extent to which students have applied their learning. It may be possible to evaluate this level through observations, interviews and self-assessments.
- Level 4 – Results – This level tries to gauge the impact of the training on the student and the end result. It may be possible to evaluate this level by comparing result expectations to actual results.

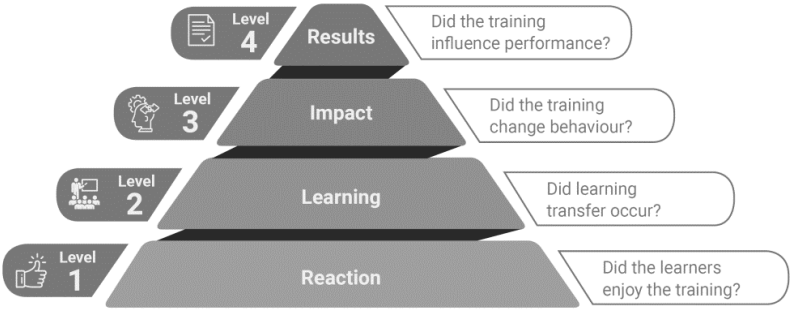

Fig. 7. Kirkpatrick's 4 Evaluation Levels [56].

Level 3 and 4 are called “impact metrics” as they deal with measurable data; whereas Level 1 and 2 are called “consumptive metrics” as they deal with aspects of consumption of learning resources by the students of the training program being evaluated by the Kirkpatrick’s 4 Evaluation Levels. Kirkpatrick model is effective to evaluate a digital learning initiative and to verify information competencies with the view of further studies as well as life-long learning [52]. Hence, Digital Learning implemented with or without Intelligent Technologies; is a perfect candidate to apply the Kirkpatrick’s Four Levels of evaluation.

3 Conclusion

This research work has been a modest attempt to address about the multiple facets of the concept of Digital Learning. The work has discussed that implementation of sudden emergence of digital learning owing to the onset of the COVID19 pandemic. This work has suggested on perceived benefits of digital learning to the teaching community and to the student community. More importantly, the work discussed at length on applications of intelligent technologies to Digital Learning. The research has also discussed about some cases about successful implementation and about application of well-known taxonomy’s such as Gagne’s taxonomy and evaluation frameworks such as Kirkpatrick’s Four Levels of evaluation. The information presented in the research, has been assimilated through meticulous review of peer-reviewed articles from more than fifty resources. The findings presented may prove to be of significance to researchers in the field, to practitioners of digital learning, creators of intelligent educational tools and any other interested parties. This research has presented the aspects of digital learning, applications of intelligent technologies to digital learning, alignment with well-known taxonomy’s and theoretical frameworks and demonstrations with real life case examples. The paper did not discuss limitations and negative aspects of intelligent technologies, as they were not in the scope of this research. These aspects may be included in the further research and related endeavors.

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