The Alternate Education for the 21st Century

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Abstract— **The purpose of the present education system is economic growth not human flourishing. Recent reports have confirmed that the emphasis on material wellbeing has been at the expense of increasing anxiety, depression, insecurity and poor interpersonal relationships. This has resulted in a worldwide call for education to adopt a more holistic approach. Building on recent research from the neurosciences that demonstrates the need to build emotional along with intellectual intelligence, we advocate a 'whole brain' approach to education to achieve human flourishing. We posit that education needs to integrate socio-emotional learning skills in addition to skills of problem solving and logical inquiry. We postulate that such transformative developments in education can be best implemented through experiential learning using digital pedagogies leveraging models of AI. We detail embedded Ontology based User Model that power 'individualized' learning through performance based trajectories with appropriate new knowledge and complexity.**

Keywords—Whole Brain Approach, Socio-Emotional Learning, SEL, Ontology, Semantic Web Technology, Digital Pedagogy

I. INTRODUCTION

The present education system can be traced back about 300 years to the industrial revolution [1,2]. It was designed to fulfill the urgent need for human capital to work in factories brought about by mechanization schooled with the basic competencies of literacy and numeracy. This produced schools designed in a similar manner to factories. The fundamental assumptions underlying this education system were (a) economic growth, measured by Gross Domestic Product (GDP) as a determinant of human wellbeing (b) human capital as a necessity for economic growth. This focus of education on economic globalization with a primary emphasis on Gross Domestic Product (GDP) resulted in extensive increase in material wellbeing. However, recent studies have indicated a disconnect between economic growth and human wellbeing [3,4]. The sole emphasis on material wellbeing has come at the cost of increasing levels of anxiety, depression, insecurity and poor interpersonal relationships [5]. According to a recent report from the World Bank [6], anxiety and stress is at an all-time high with nearly 20% of youth at risk for depression and mental health issues. These findings have led to a growing concern, challenging the economic growth-human wellbeing relationship.

In 2015, the United Nations adopted the 17 Sustainable Development Goals (SDGs) [7], a universal call to action to end poverty, protect the planet and ensure that all people enjoy peace and prosperity. Adopted by 193 nations, of the 17 SDGs, goal 4 focuses on providing 'Quality, inclusive and equitable Education' that improves people's lives and seeks to build peaceful and sustainable societies. Thus all solutions focused on providing quality education and improving human well-being must be designed to also reflect social change, cognition and brain development and technological advancement. Societal compositions are no longer homogenous but composed of diverse races, classes, and cultures, rapid advances in the science of learning from cognitive science and brain research have demystified learning process and technology as integral part of our lives capable of driving social transformation.

This places new demands on education systems and calls for a radical change in the purpose, form and content of education. It implies going beyond just materialistic wealth as the primary driver for human wellbeing but to include the notion of human flourishing. Human flourishing is traditionally defined as the state wherein an individual experiences positive emotion, acquires the abilities to achieve their own goals within themselves and with the external environment, and is able to interact positively with the social environment [8, 9]

We propose here a new model of education that seeks to focus on human flourishing and designed to nurture the whole brain [10]. We argue that a model of education that seeks to achieve human flourishing needs to be in harmony with the seat of education, namely the human brain. Models of education are uniquely human endowments and must be designed and developed to meet economic growth and provide psychological and neurobiological requirements.

A. *The Whole Brain approach – building intellectual and emotional well being*

The human brain is a remarkable organ and forms the basis for both intellectual and emotional learning. The outer layer of neural tissue of the brain in humans is called the cerebral cortex which is broadly demarcated in terms of the neocortex and allocortex with a transitional area between the neocortex and the allocortex [11] called the paralimbic cortex (Fig.1 Brain imaging experiments over the last two decades have revealed broad functions of the following three subcortices.

The neocortex which forms approximately 75% of the cerebral cortex is involved in sensory perception, generation of motor commands, spatial reasoning, conscious thought and language.

The allocortex which is much smaller than the neocortex is responsible for different kinds of memory and the olfactory systems.

The paralimbic cortex which constitutes a group of interconnecting brain structures involved in the emotion processing, goal setting, motivation and self-control and is an important part of the discussion in this paper

Broadly speaking, the paralimbic system can be conceptualized as the "feeling and reacting brain" that is interposed between the "thinking brain" and the output mechanisms of the nervous system namely, human behaviour. In order to nurture the whole brain, education must be designed to develop and nourish (the cognitive and socio-emotional parts of the brain), i.e. both the neocortex and the paralimbic cortex [10]. The paralimbic system not only regulates response to emotional stimuli but also sets the level of arousal and is involved in motivation and reinforcing behaviours. Thus, quality education needs to be structured to ensure the development of the 'whole brain' and requires focusing on building skills of socio-emotional learning in addition to intellectual intelligence [12]. Social and Emotional Learning (SEL) [13], has origins in emotional intelligence [12] and includes processes through which individuals recognize and regulate emotions, identify positive purpose, demonstrate empathy for others, take constructive action, and promote human flourishing.

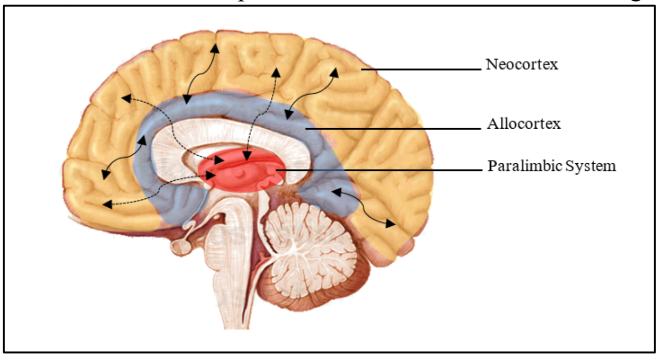

Figure 1 - Connections between neocortex and paralimbic system.

Research from the science of learning has shown that in order to learn, the human brain undergoes both structural and functional change that occurs because of a fascinating process called 'neuroplasticity', which is the ability of the brain to form and reorganize new connections [14]. Thus, a model education that seeks to build human competencies will succeed only of it is compatible with the principles of neurobiological design and development. SEL research has also shown that for learning to occur, the brain needs to be 'socially connected' and 'emotionally engaged' [13].

Thus, curricula today need to be redesigned to build a range of abilities that include not only skills of literacy and numeracy, but also critical reasoning to develop intellectual intelligence, and social emotional skills of empathy, emotional regulation and compassion for emotional intelligence [10]. It is this combined approach that will ensure 'whole bran' development and achieve human flourishing.

B. *Digital Pedagogies*

Neuroscience research has also unlocked mysteries of how learning takes place. Cognitive science research has revealed that no two brains are identical and each brain learns in a different way [15]. Since each brain is unique, education needs to be designed to include a multitude of pedagogical practices so that learning can be 'individualized' for each learner. A review of the current education systems indicates a focus primarily on extrinsic motivation measured through grades and marks, while little is done to develop or encourage intrinsic motivation which can be achieved if pedagogy is task-focused instead of reward focused [16]. Pedagogies which are designed to encourage goal or task-based learning provide opportunities to build intrinsic motivation and develop creative skills, alongside extrinsic motivation. Thus education systems need curricula that are designed to include a combination of different pedagogies like storytelling, gaming, inquiry and reflection. Such a learning environment create a multisensory, rewarding, interactive and engaging learning experience, but also ensures that the learning needs of 'different learners' are met [15].

We argue that new digital technologies available today possess the potential to transform education for the learner and have the potential to being not just 'transmissive' but 'transformative' in learning. Digital pedagogies have evolved from simple ICT platforms that transmit digitized information to transformative ecosystems that deliver a individualized learner-led interactive learning experience [17].

Digital technologies, thus, offer exciting innovative, immersive and interactive ways to facilitate a child to learn. They allow children into a world of situations to which they can relate and allow them to address circumstances and challenges that not only call upon their social-emotional skills to resolve successfully but also allow educators to test skills like planning, pattern analysis, collaboration and many others. In fact, new digital technologies when used effectively can provide narrated and animated guidance, for learning. Digital technologies allow learners to constructively solve problems and deal with life's challenges including academic ones. For educators, they provide performance measures of behavior, allow assessment of progress, and systems of progress recognition, feedback, and reinforcement given to the child.

This innovative partnership of technology with pedagogy also called 'digital pedagogy', has the potential to make learning fun, rewarding, multisensory, immersive experiential and performance based. This new ecosystem that can carve and design such a learning experience for learners. Digital technologies have already revolutionized the ways in which people make friends and communicate and the ways people shop and sell. We argue that these digital pedagogies possess the potential to transform education for the learner and have the potential to being not just 'transmissive' but 'transformative'. Digital gaming, for instance combines immersive technology with good pedagogical practice. It not only supports classroom lessons and content delivery but also provides scope for continuous informal learning as learners engage with games beyond the classroom [18].
We recommend that in this new digital ecosystem for learning, pedagogical approach and technological infrastructure can be designed prepare learners for life and work in the 21st century, mirroring in the classroom powerful

methods of learning and doing that pervade the rest of society.

C. *AI and Individualized learning*

Technology in general, and AI in particular, enables deeper understanding of learning processes, knowledge discovery, knowledge creation & knowledge sharing across borders. For creating an effective 'Digital ecosystem for Learning', learners should be empowered with the skills & knowledge that are actually relevant in the real life. The education ecosystem needs to make Learners the most 'active' agents in the learning process. Howard Gardner's theory of Multiple Intelligences [19], rooted in psychology, highlights flaws in any system that teaches and assesses every learner utilizing monolithic parameters, modes and processes. Learners have different intellectual & emotional strengths that need to be kept in mind while helping them learn, represent concepts in their minds and demonstrate their learning and current knowledge base. Learners think logically, spatially, visually, philosophically, often in an immersive, hands-on way; and AI can be leveraged to present content to learners in a way that is interesting for the learner and will be able to engage and build the learner's intelligence productively.

As elaborated in the previous section, technology can be interactive too, so that learners could demonstrate their understanding in the way that is most suited to them. This individualized learning and assessment requires thorough knowledge of the Learners which be obtained through their digital footprint enriched in both educational & non-education contexts. True individualization of learning requires cognizance of Learner's existing knowledge and complexity comprehension level to ascertain the 'sweet spot' to introduce the appropriate content at the appropriate complexity level to induce "Flow" in the learners. "Flow" is described as a state of maximum focus, dedication and immersion in learning activity.

The framework that we propose for truly 'Learner- or User-centric approach' is an **Ontology-based User Modelling Framework** [20] that models the user's most meaningful actions & behaviour according to the key aspects of the users interacting with the Knowledge & Skill-building Digital Platform. UNESCO MGIEP's indigenously developed digital Platform called **(FramerSpace),** also leverages Ontology based models. User's metadata along with user preferences, goals, needs, and interests, stored as a user ontology will constitute the foundation layer of the underlying solution architecture for Semantic Web to control user's Learning Flow. Semantic Web technology is key for moving towards collaborative, semantic-based information access. The framework explores link between user model and user activities such as: creating knowledge, sharing knowledge, learning and getting feedback based on learner's activity in the system. A 'Learner-centric' approach defined by learner's interests, goals, needs could be the basis for achieving 'Flow" in learning and can be used as the basis for establishing virtual collaborations. The characteristics of this state are the transformation of time perception and loss of self-consciousness, which means feeling that time flies and all the problems and ideas in a learner's head clear away. [21]

Ontology-based User Modelling correlates very well to Resource Description Framework (RDF) Triples linked data representations that Semantic Networks (SNNs) capture & represent very well [22, 23]. SNNs are evolved von-Neumann's Neural networks that enable SNNs to process not just the logical values but also **fuzzy** values. This is accomplished by every neuron having a unique identifier and virtual connections or Pointers between neurons. Blockchain provides an optimal structure to store these representations and various linkages between User, Knowledge & Skill Ontologies [24]. Blockchain can give confidence to certain assertions or RDF triples, and using semantic web we can link information and map data from different chains and/or contracts [25].

The application of ontology to enable semantics-driven data access and processing or semantic-enhanced search is critical. Data preparation for the SNNs includes legacy knowledge sources mapping into the knowledge domain ontology and semantically enriching the sources. For effective semantic-enhanced FramerSpace platform, advanced semantic annotation tools are developed for authoring annotation with well-defined metadata for the Legacy resources. This semantically-enriched Dataset powers better Skill & knowledge indexing and searching processes and implicitly a better Information structure. An ontology-based system can be used not only to improve precision of search/retrieval mechanism but also to reduce search time. Ontologies offer a flexible and expressive layer of abstraction, very useful for capturing the information of repositories and facilitating their retrieval either by the user or by the system to support the user tasks [25]. For these reasons, ontology-based approach for both Users & Information is at the core of the solution architecture for the development of a next generation of semantic-enhanced platform like FramerSpace.

Ontology-based user Framework has been designed as a four-tiered application dedicated to manage Learner's Digital Models. The framework architecture is modular, so that it may be extended and used for any application domain.

The Framework architecture layer [20] includes:

- **Front end UI Layer (Interface)**
- **Middleware – Business Logic Layer**
- **Ontology layer (User/Knowledge Domain/ Skill Domain)**
- **Object Layer (User Instances/ Knowledge & Skill Repository)**

The User model gets fine-tuned both *explicitly* through User profile editor available in **Interface Layer** that helps Users exercise Self-awareness & Self-assessment while editing their own profile & *implicitly* through different User modelling techniques that take into account the learning from the User's engagement with the FramerSpace platform. This User model helps provide feedback, benchmark against the social behavioural norms, compare contextual trends in peer-to-peer interactions. The **Middleware Layer** is where the individualization services reside and provide 'individualized' linkage between external requests and the data layer. Taking into account User's idiosyncrasies (preferences/context/actions/expertise), the Middleware enables UI individualization. Information access complexity, structure & modality to increase engagement, according to the User's individual preferences and observed behaviour, is calculated based on the data extracted from the digital footprints of the user interactions with FramerSpace platform and Semantic web. The **Ontology layer** is powered & represented by SNNs that enable implementation of heuristics and fuzzy logic rules that allow the logging of the interaction type, interaction scale and collaboration score of the users. Domain & User semantics are mapped into the user and domain ontology. Ontology Layer of FramerSpace platform captures & represents the relationships between different ontologies - User (Behaviour, Interest, Goal, Accessibility, Activity, Competency, Qualification, Relationship)/Content (Concepts, Domain Categories, Properties, Concepts & Sub-concepts inter-linkage) & User adaptive Interactions [20]. This layer plays a major role in developing shared understanding of terminologies and relationships globally, diluting communication barriers especially in diverse virtual communities. The **Object layer** comprises current snapshots of various system objects including the semantics of the User system interactions. It captures all the transaction logs of the User actions and the triggered events in FramerSpace platform [28].

Fuzzy classifier systems are further leveraged in the framework to assign the users to a certain category according to their level of knowledge sharing (activity log). Fuzzy logic is often used to model various types of common sense reasoning similar to a more humane way of thinking and reasoning. Fuzzy logic extends conventional Boolean logic to handle ambiguity and uncertainty or partial truth. The value between completely true and false are determined by the membership function which takes value in the [0,1]. Fuzzy reasoning was introduced by Zadeh in 1960's to handle the uncertainty of natural language [24]. We use the principle of fuzzy classifier systems in order to assign the users in different categories according to their level of knowledge sharing.

Fuzzy classifier systems imply a two-step process [20]:
- to create a fine-grained fuzzy partition;
- to generate fuzzy rules and calculate membership function or degree of membership;

Processing the activity log, Ontology based user Framework captures the level of adoption of knowledge sharing practices based on two fuzzy sets - Activity type and the Activity level to codify the membership value of a user to a certain category [28]. Change in the output value indicates a change process that brings users from their old practices to the conscious adoption of information management practices (e.g. transition from low or non-existing levels of information sharing practices to the widespread adoption of best practices in knowledge sharing) through different types of agent-based interventions.

User Data models and metadata can be used for different scenarios including: individualization, collaboration, expertise/competency discovery & assessment. Further, metadata and user modelling can be leveraged to manage tacit knowledge and implicit competencies. User ontology concepts can be mapped with the concepts of the domain ontology through properties. Thus, without requiring users to constantly update their profiles (their expertise, interests), an ontology-based platform like FramerSpace could facilitate finding the relevant domain course(s), domain experts in domains of interests for the users. Furthermore, the inferred user's expertise and interests can be used for pushing relevant knowledge, creating communities of practice or learning networks where experts and peers can collaborate, interact, communicate or share knowledge. Such mechanisms would enable to make explicit some of the competencies that a user might not be aware of and might help educators better manage their learners' competencies and skills and thus integrate personal knowledge management features into FramerSpace platform.

Finally, User modelling in virtual educational context takes on a lots of challenges like reducing information overload, additional support in learning complex concepts, traversing through diverse collaborative learning environments, individualization, optimized tools and mechanisms to share & discover tacit knowledge and getting right expert help at the right stages. To scale the model globally, to truly enable exchange of best practices for knowledge sharing across virtual communities, security considerations & policies also need to be proactively designed and enforced in the FramerSpace platform. The security protocols for Information exchange do not encompass only the information sources that the learners are permitted to access, but they also extend to the relevant regulations the educators are obliged to enforce. For rich user modelling, disclosure of user data that enables new forms of individualization, communication, collaboration and social interactions. To alleviate user's Data privacy & security concerns, we have to put the user in control of their own respective profile data. The user profile editor enables the users to enter and update personal information and thus instantiate the user ontology. It is possible to support more complex knowledge-oriented processes by exploiting the metadata and the relationships between the concepts (concept-based navigation). The advantage is the power of the relationships which enables users to navigate easily from one concept and its instances to another concept and its instances [28].

Metadata and ontology-based representations connect knowledge resources with people through contextual links among the various chunks of tacit knowledge within Open Education Resources. The collaborative and personal dimensions in virtual user personas and virtual learning environments are important features for a next generation of platform like FramerSpace. The user ontology along with user modelling processes will support a more learner-centric or user-centric approach of Semantic Web [30]. Semantic Web can be foreseen to provide more relevant content for the users integrating different sources of information, using Individualized recommendations in order to better harness collective knowledge, to reduce information overload and support attention regulation in learners, to better support users in searching for information and make recommendations of relevant content using collective intelligence, to better support lifelong learning and personal knowledge management, and/or to better help users to achieve their goal. Individualizing learning leveraging AI will be one of the defining characteristics of a next generation of services where semantics of data will play a key role along with specific goals or characteristics of the users stored in a user ontology.

D. ***Key Challenges***

SEL Curricula related Challenges

Though there is a need for socio-emotional curricula to be included in school for whole brain development there is a huge gap in achieving this. This is due to two reasons, namely lack of awareness and absence if SEL curricula in the classroom. This needs to be addressed urgently, specifically by introducing policy level changes in both awareness and teaching of SEL curricula. Regular mechanisms for monitoring such curricula are also necessary so that constant assessment and evaluation can take place.

Privacy of data

Even though, use of AI in education, as elaborated earlier, has the ability to transform and individualize the learner's experience. AI in an 'intelligent' platform like FramerSpace is able to use machine learning to adapt and respond to learners' needs in real time. As in the case of SEL embedding in curricula, lack of awareness impacts adoption of technology in classrooms too. The problems with adoption of AI is exasperated as it is the big quantum of training data, in many cases learner's personal data, that fuel these systems, enabling AI models to learn and offer actionable insights. But the scale and speed of AI growth has also raised a number of concerns and questions with respect to ethics, regulations, security, legal responsibility etc. while handling identifiable Learner's data. AI and the variety of data sets on which it often depends, only exacerbate the challenge of determining when data protection laws apply, by expanding the capability for linking data or recognizing patterns of data that may render non-personal data identifiable. Further complexity exists because personal data may be gathered for identification of a specific learner may be necessary for AI to recommend action and make a decision.
Finally, while data protection laws attempt to protect sensitive data and similar variables, technologists would argue that algorithms need to include such data in the analysis to ensure accurate and fair results. Moreover, such data may prove useful for human intervention to review and mitigate discrimination or bias. Understanding and resolving the scope of data protection law and principles in the rapidly changing context of AI is not an easy task, but it is essential to avoid burdening AI with unnecessary regulatory requirements or with uncertainty about whether or not regulatory requirements apply [31]. In a nutshell, the data privacy aspects of AI are not very well understood by the practitioners and even for regulatory framework architects to keep up with the speed and scale of growth of applied ML models for public interest is becoming increasingly challenging.

Data Bias

Further challenge of employing Machine learning (ML) models in learning context is that they are not inherently objective. ML models are trained by feeding them a data set of training examples, and human involvement in the provision and curation of this data can make a model's predictions susceptible to bias. ML models, at their core, are predictive engines. Large data sets train machine-learning models to predict the future based on the past. Models can read masses of text and understand intent, where intent is known. They can learn to spot patterns & trends by consuming millions of pieces of data (Labelled or unlabelled). The advantage of machine-learning models over traditional statistical models is their ability to quickly consume enormous numbers of records and thereby more accurately make predictions through trends that Humans may otherwise may have missed. But since machine-learning models predict exactly what they have been *trained* to *predict*, their forecasts are only as good as the data used for their training. Common human biases can manifest in ML insights if proactive steps are not taken to mitigate their effects. Any sort of skew in the data, where certain groups or characteristics may be under- or over-represented relative to the real-world prevalence, can introduce bias into the model distorting the insights from ML models.

E. ***Key Opportunities***

Inclusion

Although the technologies that are currently available have had a positive impact on educator's abilities to deliver the curriculum, learners who have disabilities are often overlooked in the development and provision of these tools and, as such, they do not benefit from the same learning experiences as those without disabilities. As previously elaborated, the important role that ontologies can play in the development of Individualised e-learning experiences has been acknowledged by many researchers. However, at present, those ontologies that have been applied to individualized e-learning are largely limited to taxonomies of user interests and there is a distinct lack of an ontological approach that effectively integrates learner preferences, assistive technologies and special needs in one ontology [6]. The assistive technologies involved in the ontology incorporate flexible settings that can be altered in accordance with the learning needs of the learner who is using the system. The use of a domain ontology to develop assistive learning technologies that can be aligned with the needs and capabilities of learners with differential abilities is the next organic step. Two fundamental aspects are of interest: the learning styles that learners with differential abilities exhibit, and how assistive technologies can be adapted to align with these learning behaviours [32]. Through taking differential ability type into consideration when developing the learning objects, it is possible to develop a platform like FramerSpace that is capable of aligning the resources presented with the learner's learning needs and capabilities. This mapping provides the levels of adaptation required to ensure that FramerSpace platform integrates seamlessly the assistive technologies needed to deliver learning experiences that are appropriate to the learner's needs.

Scaling up

AI- & Analytics- powered FramerSpace platform has allowed educators to have a more comprehensive view of learner learning and performance. As systems become more integrated and better able to continuously track data at a detailed level over time, they can offer educators and policy-makers a better understanding of learner achievement in the context of educator performance, course design and other areas. Technology is allowing learner data to be generated from an increasing number of sources, ranging from more traditional learner information systems, which collect enrolment, course history and achievement data, to classroom lessons, activities and digital instructional content platform. In addition to collecting data, new age FramerSpace platform has tremendous potential to indirectly facilitate the development of 21st-century skills such as collaboration and communication as learners interact with digital content and with each other.

Individualizing education

Individualised and adaptive education technologies are attempting to deliver differentiated learning with one-on-one virtual learning tailored to individual learner needs, often used effectively with blended-learning approaches mixing in-person and online instruction. These programs can be used in conjunction with in-classroom instruction, freeing up educators' time to deepen learners' understanding of the material and to develop skills like problem-solving, creativity and collaboration. They can also harness the power of data to dynamically assess learning, address gaps and track outcomes.

AI-powered FramerSpace platform can provide the back-end analytics necessary to offer an adaptive experience to learners and provides an engine that allows others to build adaptive learning applications and experiences from a wide range of content, as well as to assess what works best. FramerSpace platform enables educators to create "adaptive pathways" for the lesson materials they create. This allows educators to design a unique and differentiated experience for learners.

Further, games and interactive simulations embedded organically in pedagogy allow learners to go beyond the traditional lecture and to interact with instructional content in an engaging way. Games allow a focus on multiple skills at once: while learners work to improve their understanding of core concepts, they can also develop skills such as creativity, curiosity and persistence in the process. These tools, along with new pedagogical approaches such as project-based learning, are therefore at the forefront of addressing skills gaps in competencies and character qualities.

F. Conclusion

This paper proposes the design of an alternate education system that is structured to promote human flourishing with roots in neuroscientific design to nourish the 'whole brain'. This education system seeks to harness the power of modern digital technology to create a new ecosystem of digital pedagogy and thereby deliver individualised learning. It presents an ontology-based approach to develop an individualized learning platform like FramerSpace that creates adaptive content based on learner's abilities, learning style, level of knowledge and preferences. In the approach, ontology is used to represent the content, user and domain models. The Ontology based User model describes learner's characteristics required to deliver tailored content. The domain model consists of some classes and properties to define domain topics and semantic relationships between them. The content model describes the structure of courses and their components. The system recognizes changes in the learner's level of knowledge as they progress and the ontology based user model is updated based on learner's progress and the passage from one disposition of learning process to the next is determined based on the updated learner's profile. The paper also details the whole brain approach with the challenges and opportunities that use of technology, specifically Games & AI, can present in the context of Learning. Finally, we posit that integrating training in intellectual and socio-emotional skills, specifically critical inquiry, mindfulness, empathy and compassion, will create responsible and caring global citizens who are aware of the consequences of their choices. This integration is critical in order to achieve the desired objective of re-orienting the purpose of education to human flourishing and well-being.

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