On Measuring Learning Success of Students with Disabilities in Virtual Environments

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During more than the last three decades, the interest in educational arena supported by technological advancements has been growing systematically. New, different, concepts and tools including: Innovative Educational Environments, Future Classrooms, and Virtual Laboratories emerged constantly, introducing innovative ways of e-learning. On the other hand, Inclusive Education is getting more attention and importance, as contemporary classrooms must include students of diverse abilities, to learn and socialize together. The modern classroom should not discriminate between students with disabilities and students without disabilities by offering them equal attention and opportunities. In this position paper, our intention is to consider possible technological influences on Virtual Environments/classrooms having in mind Science, Technology, Engineering and Mathematics (i.e. STEM) education and, accordingly, propose some possible measures for learning success of students with disabilities. The key issue in these activities is to make all students feel welcomed and properly supported in their efforts to gain adequate knowledge and skills, while collaborating with their peers and interacting with e-learning environments.

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1 INTRODUCTION

During the last several decades (As a very basic example of considerations concerning use of technology in education that have been formulated almost 30 years ago see, for instance, this references list[2]), the interest in education supported by technological advancements has grown enormously. New, creative learning environments emerged constantly, exhibiting highly promising features, for advancing the educational arena. Virtual, multi-functional environments and classrooms determine the more active involvement of teachers and students, supported by advanced pedagogical approaches enabled by modern digital technologies. Challenging technological, pedagogical and methodological approaches, in educational processes, promote positive impact on students' academic knowledge, skills, interaction and levels of technological literacy. Technology

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[2] http://www.ibspan.waw.pl/~paprzyck/mp/cvr/education/neted.html

enhanced learning assure flexible, responsive, and effective use of digital technology [Patrícia and Neuza 2018].

Technological advancements are also directly influencing Inclusive Education. It is important that students of diverse abilities and backgrounds get learning and socializing together in the same classroom. However, such new way of learning and socializing needs significant educational reforms, at least in the area of adequate teacher and staff training, as well as the availability of technical support and adequate learning materials tailored to specific students' needs. Inclusive education, in essence, means that students with diverse abilities and backgrounds learn together, in the same classroom (real or virtual/distance) by receiving high quality support that is needed to achieve success in the core elements of the proposed curriculum. The modern classroom should treat the students with disabilities (SwD) as being, fundamentally, as competent as students without disabilities. Technological advancement in ICT, especially in domains like robotics, mechatronics, and artificial intelligence, together with innovative instructional design and novel pedagogical approaches, are essential premises for the successful inclusive education, regardless of student differences and of their diversity in cognitive, academic, physical, social, and emotional traits [Savin-Baden 2015].

Students with disabilities have specific, individual learning needs, as well as restricted learning abilities. So the pedagogical methods have to be oriented towards developing unconventional teaching practices, adequate educational resources, and they should apply specific assessments supported by adjusted measures of learning success. Distance learning, as well as mobile learning supported by the use of tablets, smartphones, and similar devices, may offer innovative solutions for adequate education of SwD. Mobile applications and special educational tools with speech-to-text and text-to-speech functionalities can highly support SwD by enabling their fair engagement in the learning/teaching process, regardless if they are in real or virtual classrooms.

In their early days, distance learning and e-learning were concentrated predominantly on narrative disciplines, without the need to use laboratories and hands-on activities that characterize (Science, Technologies, Engineering and Mathematics) STEM disciplines. Modern technologies strongly contributed to the inclusion of these disciplines into the focus of distance and e-learning education, by providing adequate technological support, like for example the development and application of online virtual laboratories for students of science and engineering disciplines (mathematics, informatics, physics, robotics, mechatronics, control systems and so on). In such specialized virtual laboratories a student can exercise specific practical tasks regardless of time or location boundaries, fear of improper handling of equipment, requirement for a live instructor (who will be replaced with Pedagogical Agents and Chatbots) [Terracina et al. 2016].Here, the good news is that important early issues related to, broadly understood, computer literacy (see, for instance [Paprzycki 1992]) have almost disappeared across the "developed world".

Additionally, great potential lies in use of Internet-of-Things (IoT) and Internet-of-Everything (IoE) that enable virtual use of various smart and specialized devices, thus making learning easier, faster, and safer. These innovative approaches bring about incredible potential for students with disabilities as well, by enabling them to learn from homes and, at the same time, to interact and collaborate with their peers and teachers.

In this position paper we concentrate our attention on possible technological influences on Virtual Environments and on some possibilities to measure the performance of such systems, in order to increase learning success of students with disabilities.

The remainder of the paper is organized as follows. Different contemporary technologies and their influences on learning of students with disabilities are presented in Section 2. Deeper considerations of measures for learning success of SwD and proposition of most appropriate characteristics of

Pedagogical agents in social aspects of learning, are given in Section 3. Last Section brings concluding remarks.

2 TECHNOLOGICAL INFLUENCES ON LEARNING OF STUDENTS WITH DISABILITIES

Continuous technological influences on improvement of classroom flexibility, development of modern teaching methodologies, usage of e-services, mobile/smart devices and social media should be adapted for students with disabilities. Current worldwide revolution that is happening in the education (in both real and virtual classrooms) is initiated by numerous applications of Internet of Things (IoT) and Internet-of-Everything (IoE).For example, the paper [Farhan et al. 2018]shows that activities of students in an e-learning environment can be effectively measured using an attention-scoring model (ASM). The model is based on the observation of students' faces and eyes in order to discover their attention and emotions. The IoT can have implications on the overall delivery of the educational material in highly innovative manner in all aspects of students' activities. IoT, intelligent technologies and new concepts, such as cloud computing, educational and learning analytics, wearable technology, etc. promote the materialization of smart education.

Availability of a wide range of multimodal educational resources that are at students' disposal and that can enhance teaching and learning rapidly increases in the emerging world of the IoE. While IoT represents the networked connection of different physical objects, IoE represents a network of smart objects, i.e. interconnected things where the difference between the physical object and the digital information augmenting them is blurred [Selinger et al. 2013]. The huge number of connections of people (including students and teachers), processes, data, and other things brings about a completely novel concept of Internet of Learning Things [Selinger et al. 2013]. Inclusion of IoE in educational activities, with the aim to improve learning and assessment capacities is seen as highly promising, more sustainable, and challenging future direction. Different universities and companies, all over the world, strive in development of IoE-based smart classrooms that include numerous highly heterogeneous devices: smart tables, interactive whiteboards, 3D printers, sensor gloves, eye-trackers, headsets attention monitoring systems, Human-Computer interfaces, and other digital laboratory devices. Such devices support reducing different obstacles and barriers faced by students with disabilities, such as physical, cognitive, social and organizational barriers. Human-Computer interfaces, supported by suitable technical devices, are an essential element to support all students in virtual educational environments. The developed IoE-based smart educational environments can enable a completely revolutionized learning and teaching practice, for students with disabilities, in STEM disciplines.

2.1 Role of E-Learning Environments in Educational Processes

During the last decade, a wide range of software systems, enriched by including numerous and diverse aspects of multimedia and Web technologies, and seamless, multimodal, user-friendly Human-Computer Interaction, have been developed for promoting innovative and smart learning.

One such general purpose Learning Management System that is probably mostly used nowadays is Moodle. Its development was based on sound pedagogical principles, and it can support diverse e-learning approaches, including distance education, flipped classroom and blended learning. Since its introduction, about two decades ago, many improvements and enhancements of Moodle have been developed [Open Source Technology 2014], [Link1] to follow requirements of ever-changing educational demands. Constantly innovated Moodle environment helps educators to build multimodal, multifunctional, and interactive e-lessons. There are a lot of additional educational services and components that can enhance Moodle in order to improve classroom flexibility and offer pleasant learning atmosphere, for all diverse categories of students.

Apart from technological advancements, pedagogical aspects are of paramount importance for modern distance educational environments. The preparation of educational resources, for Virtual Environments and students with disabilities, to support accessibility with wide range of functionalities, must be based on non-conventional hardware and software components such as upgraded keyboards, speech-to-text and text-to-speech functionalities, scalable fonts, and so on, by augmenting the Virtual Environment with:

- multiple formats (HTML, RTF, PDF, etc.), to ensure acceptability by a wider range of students,
- multiple modalities (visual, auditory, kinesthetic, or tactile)to increase students' motivation and interest,
- more flexible course materials to accommodate students' differences and diversity,
- innovative use of modern multimedia technology supported by educational data mining and learning analytics to obtain high level of personalization and tailored recommendations.

Additionally, today's innovative learning models and concepts, like flipped classrooms [Lage et al. 2000], serious games, and massive open online courses (MOOCs), are constantly progressing and enable more students (especially for students with disabilities) to engage from more and diverse locations at a wider scale in higher quality education using adequately prepared educational resources.

Regardless of these general purpose systems, worldwide research and academic institutions have been developing their own, specific-purpose, usually intelligent and personalized educational systems/environments. They are extremely important in facilitating higher-quality STEM e-learning [Klašnja-Milićević et al. 2017]. An essential feature of such systems is personalization that provides open, flexible, and tailored learning to students with diverse abilities.

Key desirable features of a wide range of e-learning systems include new models for intelligent personalized interaction and teaching material recommendation. These particular intelligent personalized interactions are usually required to address the specific and personal needs of each student, including: learning style [Klašnja-Milićević et al. 2011], personal learning characteristics of the learning style (like: Discussion forums, Simulations, Roles and serious games, Case studies and so on), as well as the most suitable electronic media for representation of educational resources (e-book, Forum, Wiki, Weblog, Podcast, and so on).These numerous possibilities to enhance traditional learning provide students with disabilities better access to information based on visual, auditory and kinesthetic means. At the same time, the teacher and peer's interaction and collaboration with SwD can be significantly improved. With the availability of numerous online collaboration tools, existing today on the market, student-teacher and student-student interaction has never been easier. Innovative ICT technologies (cutting-edge multimedia, speech and mobile technologies, IoT and IoE) improve accessibility and contribute to the transition of teaching from a traditional "one size fits all" approach to more individualized "one size fits one" learning solutions that are more appropriate for students with disabilities.

In order to provide accessibility to literature for students with sensory, physical, cognitive and psychosocial disabilities, the development of multimedia libraries and enhanced virtual laboratories based on speech technologies is a challenging task [Lynch and Ghergulescu 2017]. Virtual laboratories offer new way to students' participation and interaction in inquiry-based classes. In such classes students can perform their own experiments, learn from anywhere (by using virtual objects).As another opportunity, multimedia libraries can enhance standard lecture presentations, with accompanying explanations in both textual and audio forms (using, for example, Pedagogical agents – see, the next sub-section).With the help of IoT, the audio form, in general, can increase the accessibility of the educational resources to the visually impaired, while the textual and visual parts

of educational resources will make it more accessible to the hearing impaired students. The utilization of speech-enabled mobile applications, for example, helps students with reading related disabilities to access educational resources and assists students with writing difficulties to finish their writing tasks. IoE-enabled devices and technology help students to access their courses at any time, from anywhere in the manner most appropriate to them.

A very challenging issue, in this area that was recently taken into consideration is the appropriate capture, stimulation and use of human senses. It is regarded as one of the prominent practices of the educational process. Multi-sensory instruction is described as teaching that involves all the senses: seeing, hearing, tasting, touching and smelling [Aleksandra Klašnja-Milićević et al 2018a]. Multi-sensory instructions, together with abovementioned innovative approaches, enhanced by augmented reality technology, offer highly promising elements that can obtain new functionalities in virtual learning environments for students with disabilities. For example, NEWTON project [Lynch and Ghergulescu 2018] encompasses augmented reality with personalized learning and virtual reality with gamification and emphasis on developing virtual laboratories tailored to the specific needs of students with disabilities.

2.2 Role of Pedagogical Agents in E-Learning Environments

Research in Inclusive Education area show sthat the presence of SwD gives non-SwD students new kinds of learning opportunities[Savin-Baden 2015],[Savin-Baden et al. 2019]. In such learning organization, one significant opportunity occurs when non-SwD serve as peer-coaches. In fact, by trying to help another student, the helper peer can improve his/her own performances (see, also [Paprzycki and Vidakovic 1993] and references collected there).

Another challenge is connected to the teachers' duties. To take care of their more diverse audience, including students with disabilities, teachers must be able to provide instruction in a wider range of learning modalities (visual, auditory, and kinesthetic) bringing benefits also to their non-SwD. This task is definitely not easy for majority of teachers. However, using contemporary technological advancements this problem could be successfully solved in near future using intelligent software agents.

Autonomous, intelligent software agents, used in a learning context, are usually known as Pedagogical Agents. Their aim is to support learners across a wide range of subjects. Pedagogical agents are especially valuable to guide students through multimedia, multimodal learning environments, by exploring their motivations and by assessing the learning effects and outcomes. The use of Pedagogical Agents ranges from supplementing existing human-driven instruction with expert features, to entirely replacing human teachers. "What is required is the use of such agents in places of widening access, increasing diversity, and spaces that work against standardized models of learning." [Savin-Baden et al. 2019]. In the paper [Rickel et al. 2002] authors presented Autonomous (Pedagogical) Agent as a kind of software that conveniently interacts with the user, possibly using natural language, in form of: conversation, coaching to achieve solution of particular task or posing questions to assess acquired knowledge. The desirable form of these agents is to be realized as virtual visual assistants. Additionally, Pedagogical Agents have been found to improve motivation and reduce cognitive load among the students [Bowman 2012], [Ivanović et al. 2015].

Pedagogical Agents are used for learning purposes in different domains and courses. However, in the context of this paper, our intention is to present their advantages in STEM domains, with emphasis on students with disabilities. For this purpose, interesting experiments were performed in subjects spanning STEM with the AutoTutor system [Graesser et al. 2014], and for learning programming with the PROTUS system [Ivanović et al. 2015]. In these systems, students have to gain adequate knowledge and develop their problem-solving skills. Pedagogical Agents used in these systems are aimed at providing students with a virtual tutor that can respond intelligently to their

inquiries and that has the ability to emulate the teacher by offering students immediate feedback and hints, thus helping them to improve their knowledge and skills.

Virtual Pedagogical Agents/Tutors raise difficult challenges and offer great opportunities to be faced and exploited in virtual e-learning environments and laboratories that provide technologically supported inclusive education. One of very important aspects, during learning for students with disabilities, is attitude – a complex psychological concept that characterizes the mental and/or emotional state of a person [Perloff 2016]. Therefore, the use of Pedagogical Agent as a motivator that demonstrates positive attitudes towards the task and the desired levels of performance, helps students to cope with situations where they feel as novices or with some level of anxiety.

One-to-one communication between student and system is valuable, especially for students with disabilities, and it can help enormously in acquiring curricular knowledge and skills. However, other personal diversities (like social and emotional) also play important role in multiple educational activities. Moreover, recent approaches that target the realization of mixed group interactions and conversations between agent(s) and students are getting more and more attractive for students with disabilities. For example, a notable approach presented in [Graesser et al. 2014] concentrates on trialogues, i.e. some simple way of group conversations. In fact "The incremental value of multiple agents is that the student can learn by observing how the agents interact. A student can learn vicariously by observing one agent communicating with another agent, showing how actions are performed, and reasoning collaboratively with the other agent."[Graesser et al. 2014].This paper highlights situations where two agents can behave in different circumstances such as: disagreement, contradiction, and holding an argument, thus providing the students' with the opportunity to face different situations that can appear in real classrooms.

This very interesting approach can represent an excellent starting point for further investigation in this area, aiming at bringing useful consequences for students with disabilities, in supporting their social and emotional aspects of learning. The development of future e-learning environments must investigate if such virtual multi-conversational Pedagogical Agents actually encourage or discourage the development of problem solving, reasoning, and, in-depth learning of students with disabilities. Future investigations and experiments also have to include different configurations of students in both situations: (1) real classroom with blended learning style or in (2) Virtual Environments, where the use of chat forums is highly encouraged in both situations. For example, it will be interesting to consider the following learning scenarios in which mixtures of both types of students (SwD and non-SwD) are included in the same group:

- **Scenario1**: Real classroom with a blended style of teaching/learning with the possibility to use chat forums.
    - group of several students (including students with disabilities) communicate with one Pedagogical Agent;
    - one student with disabilities communicates with several Pedagogical Agents;
    - group of several students (including students with disabilities) communicate with several Pedagogical Agents;

- **Scenario2:** Virtual Environment with direct communication or by using chat forums:
    - group of students can communicate with one Pedagogical Agent
    - group of students can communicate with several Pedagogical Agents.

Students can either communicate directly or exchange messages and then expect the opinions and suggestions of their peers, as well as of Pedagogical Agents.

Such scenarios and experiments, with different mixed groups of students, could bring valuable insights into the pedagogical, methodological and motivational aspects of inclusive education

supported by contemporary technologies. However, currently this task is not easy, in spite the fact that different frameworks for communication using natural languages offer great opportunities, like for example Amazon Alexa and IBM Watson.

3 MEASURING LEARNING SUCCESS – STUDENTS WITH DISABILITIES

Measuring students' learning success is one of key activities in all educational processes. One can find a lot of different definitions (on the Internet, in books, and research papers) of learning success. Some of them are rather complex and comprehensive, so in the paper we will concentrate only on several key aspects important for students with disabilities. We focus on learning success that considers the level and quality of acquired curricular knowledge, including social aspects i.e. interaction and collaboration between students and teacher (real or virtual). Diverse measures of learning success have been developed constantly, with main motivation to help in improving methods, pedagogies and adjust learning activities to specific and particular students' needs [Davis 1993], [Lorenzo el al. 2013], [Byers 2017]. These measures are oriented towards obtaining subjective, or objective, evaluation of educational practices. Triggered by the contemporary necessity to take special care of inclusive education, existing measures have to be re-considered and re-evaluated under new circumstances, such that updated, as well as novel instruments must be proposed.

Modern trends and technologies like educational data mining (EDM) and learning analytics (LA) offer instruments to answer increasingly important, but very complex, questions: what is the current student knowledge level and whether a student is actively engaged in the learning process together with her peers. Scientists, from different disciplines, connected to educational processes have actively considered and experimented with new techniques, based on machine learning and data mining from system-generated data that have shown promise for predicting students' learning achievements and outcomes. They analyzed students' behavior in learning environments, trying to recognize their different learning patterns, for possible later use in predicting further students' learning activities and achievements, in order to increase quality of learning [Klašnja-Milićević and Ivanović 2018b].

3.1 Measures for Learning Success of Students with Disabilities

In this sub-section we will consider some, possible, "general-purpose/standard" measures that can contribute to the advancement of technology enhanced learning of students with disabilities.

MEASURING LEARNING SUCCESS - CASE 1: Rather than a standard way to measure learning success and effects of learning, considering 3 specific learning situations is presented in [Savin-Baden et al. 2019]. Authors considered students with different abilities and background and they allocated them into one of three conditions. First group consisted of students that used support of Pedagogical Agent. Second group consisted of students that used on-line teaching material. Third group consisted of students that have traditional face-to-face session. Qualitative data was collected through semi-structured interviews, while quantitative data was collected through both objective (target subject attainment) and subjective (technology acceptance and learning approaches) self-reporting measures. Technology Acceptance Model form (TAM) [Davis 1993] [Lorenzo et al. 2013] was used to assess the usability and perceived usefulness of the Pedagogical Agent. The ASSIST Questionnaire form [Tait et al. 1998] was used to evaluate students' learning approach, i.e. to check if the approach with the agent engagement is more effective. Analysis and final drawn conclusions showed that, at the moment, students from the three groups prefer more the Online and traditional F2F approach as compared to the Pedagogical Agent approach. Specifically, "for the Pedagogic Agent groups, scores on the measure of technology assessment, the TAM, were highest for computer playfulness and lowest for computer anxiety. For the Online group, scores were highest for the perception of external control and also lowest for computer anxiety."

As Pedagogical Agents can offer additional methodological advancements and support in variety of educational settings, they must be carefully considered and especially used in inclusive education. Accordingly, we can suggest and conclude: to use Pedagogical Agents in inclusive education, students need to be supported in understanding their preferred learning strategies, as well as to be able to build on individual self efficacy to promote more effective engagement.

MEASURING LEARNING SUCCESS - CASE 2: In this case, a rather innovative approach of measuring students' learning success is discussed. A specific kind of learning observation metric entitled Linking Pedagogy, Technology and Space (LPTS) was developed by Terry Byers [Byers 2017]. It supports "real-time empirical evidence of spatial interventions by teachers through their practices and subsequent impact on students." This, rather comprehensive, measure covers five aspects of learning: Pedagogy; Learning Experiences; Communities of Learning; and Student and Teacher Use of Technology. The measure was designed to determine the duration of each activity and its behaviors associated with 36 indicators. The time spent in each activity and associated behaviors are recorded as they occur during the learning process [Patrícia and Neuza 2018].

For **Learning Experiences**, the following indicators are assigned: formative assessment, receive instruction, remember/recall, understand, apply, analyze, evaluate, creation/practical activity, students disengaged. For **Communities of Learning**, the following indicators are assigned: individual, small groups (the same number), whole class, mixed groups (different numbers), mixed-class/year-level. For **Student and Teacher Use of Technology**, the following indicators are assigned and they are the same for both participants: mode1: teacher-centered, mode2: student-centered, mode3: informal, outside classroom, substitution, augmentation, modification, redefinition, pen and paper, tablet/laptop (typing), tablet/laptop (touch or stylus), front data projector, additional visual display/screens, whiteboards (writeable walls), camera or recording equipment, equipment or tools. Obviously, it is possible to find indicators in each category that could be considered for use in inclusive education. However, because of limited space of the paper, from the point of view of inclusive education and success of students with disabilities, we focused here only on the **Pedagogy Aspect** of the measure. This aspect includes the following indicators [Patrícia and Neuza 2018]:"

- **Didactic Instruction**- when the teacher is engaged in presenting/disseminating content, concepts or information to students through a didactic/direct instruction mode;
- **Interactive Instruction**- when the teacher is engaged in demonstrating a process/ability or skill through an interactive/dynamic instruction mode (using equipment and/or tools through a series of interactive steps);
- **Facilitating**- when the teacher is moving about the room to observe/monitor/regulate students' progress and behaviors;
- **Providing Feedback** - when the teacher provides feedback (advice, direction or suggestions) on an individual, pair or small groups progress in a particular learning activity;
- **Class Discussion**- when the teacher promotes the instruction/discussion with the students/between the class to provide input to a particular topic of discussion that they or the whole class are participating in; when students interact/discuss with each other
- **Questioning**- when the teacher asks the student(s) (individual, pair, small groups, whole class)to answer or respond to either closed or open questions about the thematic contents/ activities."

Original definitions of indicators have to be adapted depending on specific characteristics of experiments and educational circumstances. Concerning the role of Pedagogical Agents and the possibilities to use them in different communication scenarios, during learning processes of students with disabilities, the last three indicators can play a significant role from our point of view.

The social aspect of learning is generally very important, especially for majority of STEM disciplines. It seems additionally valuable for students with disabilities. Concerning the indicators

mentioned above: **Providing Feedback, Class Discussion** and **Questioning,** the value of student-teacher dialogue for students with disabilities has to be considered with special attention. Concerning Scenarios proposed in Section 3.1, all explanations of Pedagogical Agents depend on two basic processes that students must be engaged in, especially when on-line discussions are in use:

- "speaking"- externalizing ideas/opinions by posting messagesto the discussion forum;
- "listening" - consuming the externalizations of others by accessing existing posts.

Speaking, in on-line discussions, is visible to other participants, while listening is invisible, and it, is in fact, the critical issue for discussions here. The different kinds of listening behaviors represent step ahead in productive use of discussion forums. It is important to motivate students to be actively engaged and support better connections in student-student and student-teacher listening and speaking behaviors [Wise et al. 2013].Pedagogical Agents engaged in virtual learning environments can highly motivate students to actively participate and regulate/decide how they will speak and listen in online discussions. Having appropriate communication skills, Pedagogical Agents can positively influence students with disabilities for their active and productive participation in **Class Discussion** and **Questioning.**

Analysis of data collected from discussion forums (especially if we use educational data mining and learning analytics) could be extremely useful in **Providing Feedback** from Pedagogical Agents and tailoring and personalizing actions suggested for each individual student with disabilities.

For achieving this constructive supervision and tutoring of Pedagogical Agents, some basic measures can be considered in data collection phase like: Range of participation, Number of sessions, Average session length, Number of sessions with posts, Number of posts made, Average post length, Number of posts read, Number of reviews of own posts, Number of reviews of other's posts.

Additionally, as interaction/conversation has visual and audio nature, we can valorize the additional power in the identification of frequently used words/phrases and the basic elements of text and speech analysis that can significantly improve the personalized feedback provided by Pedagogical Agents.

3.2 Measures for Empowering Students' Interaction and Motivation

Different methodologies for qualitative and quantitative measurement of learning success are necessary in order to increase the quality of learning. They are especially important in technology enhanced learning and, in particular, when employing Pedagogical Agents in Virtual Environments/classrooms. Recent investigations in the area of inclusive education show that, when mixing both students with and without disabilities, both groups have the opportunity to learn more. Many studies carried out over the past three decades have found that students with disabilities obtain higher achievement and improved skills through inclusive education, while their peers without challenges can benefit, as well[Bui et al. 2010], [Alquraini and Dianne Gut 2012].

Adequate measures (regardless if they are objective or subjective)must be used, to help in empowering personal communication, to provide better recommendations of appropriate educational resources and to increase the motivation of students. To summarize previously presented possibilities to measure students learning success, we can suggest several possible main domains for measuring learning success of students with disabilities in virtual learning environments.

Measure1: **Learner-centeredness**– provides the students with the opportunity to actively participate in the teaching and learning process; supports learning; students are regarded as contributors to their own learning [Makoelle 2014].

Measure2: **Learning preferences**–students' learning approaches and preferences highly affect their engagement with the Pedagogical Agent(s); such preferences influence the process of teaching material tailoring and personalizing, in order to serve the special needs of students with disabilities.

Measure3: **Virtual interaction**–these measures should offer opinions and suggestions for further learning steps given by Pedagogical Agent and they are crucial for participation of students with disabilities in virtual classrooms. For SwD, additional important measures should be oriented towards assessment of visual appearance and interaction with Pedagogical Agent like:

- *General characteristic* - age, gender, clothing, weight, etc.;
- *Quality of voice*- high, medium, treble, etc.;
- *Emotion expressions* - compassionate, pleasant, strict, polite, etc.;
- *Additional emotional factors*- boredom, pride, pleasure, shame, etc.;
- *Monitoring and directing motivation* - arouse interest, highlight the relevance of the topic, strengthen the student's confidence, etc.;
- *Capabilities*- behave as expert (strict), motivator (friendly), and mentor (supportive);
- *Human vs. non-human characters*- appearing to be as static or animated;
- *Communication mode* - students can freely choose if and when to chat with theirPedagogical Agents.

Measure4: **Team dynamics**– Teamwork is an important way of organizing manpower in activities leading to producing solutions, in majority of STEM disciplines. Grouping students in Virtual learning environments is an additional motivational factor for all group members regardless of how diverse they are.

Measure5: **Cognitive abilities**–characteristics of the students who interact with the Pedagogical Agent(s) include several cognitive factors like: prior knowledge, ability to integrate the new information into the existing cognitive structure, ability to share knowledge and so on.

Measure6: **Information processing**– provides explicit information about prerequisites, conditions, relationships or outcomes of the learning content, enables students to decompose new information into smaller units, synthesizes them and is able to extract similarities and differences.

Measure7: **Transfer of information**–the ability of students to apply the new knowledge, to transfer it to other topics, and to use it for solving new problems.

Contemporary learning, usually represents a challenging and unique mash-up of home-school-work-media-peer-collaboration in both real and virtual classrooms/environments. It includes also the following significant practices (based on [Savin-Baden 2015]) that are applicable to students with disabilities, granting them equal opportunity in educational processes:

- **Mentorship** -using mobile devices to keep in touch with various educational players through different means of communication including ubiquitous social media.
- **Co-operative online learning** - cooperation with peers and virtual agents to guide and support completing homework, assignments, tests. Similar measures as abovementioned could be applied here.
- **Gaming**: isolated or combined in order to share, teach, learn, offer advice, negotiate, and give and receive hints, tips and solutions.
- **Teaching technology**: teaching and sharing experiences with peers and virtual agents about applications, services, new devices, and helpful sources of information.
- **Emotional learning**: using digital media for peer to peer support to manage personal issues and difficulties, and to receive hints and advice.
- **Playful learning**: trying things out and fiddling around, in order to experiment and discover.

All these practices additionally attract research community attention, influence further research and raise a lot of interesting research questions in order to find and propose adequate new measures

or evaluate and adjust existing measures to meet requirements of inclusive education and higher learning effects of students with disabilities.

In this position paper we pointed out initial considerations and proposals for establishing measures for virtual learning environments with Pedagogical Agents that can help students with disabilities to achieve better learning success and interaction with peers and teachers (real and/or virtual).

4 CONCLUDING REMARKS

Continuous and rapid technological advancement essentially changes our traditional perceptions of education. Numerous emergent technologies appear "on the monthly basis". Impressive growth of availability of IoT and IoE smart devices with sensing / actuating capabilities and applications that can take advantage of them bring enormous potential in education and can significantly change its pedagogical and methodological aspects. They are excellent facilitators for contextual, personalized and seamless learning in smart environments, suitable for students with disabilities.

Having SwD and non-SwD in the same classrooms (real and/or virtual) is challenging for the wide range of educational stakeholders. Henceforth, investment in designing and establishing appropriate success measures of such systems can benefit students learning success and thus is an important task. Moreover, active participation of students in these efforts is crucial for full success. Involving students, asking for their opinion and suggestions is unavoidable and highly relevant. Brookfield and Preskill [Brookfield and Preskill 2012] suggested and interesting approach and method for helping students to create their own ground rules. These suggestions also can represent a good starting point in preparation of specific measures of virtual learning environments (based on Pedagogical Agents) for students with disabilities, allowing them to assume a more active role towards increasing their learning success.

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