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Augmented Minds: Technology's role in supporting 21st Century Doctors

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Abstract. The issue of preparedness of medical students to work as junior doctors has come under increasing scrutiny. One of the key challenge for tomorrow's doctors is the capacity and engagement for continuing professional learning and development, as well as, appropriate decision making. consequently, medical schools are exploring various ways in which technology can support this and this includes preparing students for work-based learning as well as enhancing the work-based learning placements. This includes the augmentation of the learning process with the development and consumption of digital content and electronic resources of interactive character to support issues around complex problem solving, decision-making and clinical management. Virtual patients and scenario based learning activities as well as the concept of Living Labs may be used in the preparation for the workplace activity, and thus to enhance the effectiveness of medical student work-placements. Mobile learning, reflective learning and coaching tools are being used to support students' reflections and action planning whilst on work-based learning placements. The scope of this paper is to provide a vision as to how related technologies and associated pedagogical models may be engaged to augment workplace learning and professional development and to digitally empower the medical professional. Emphasis is placed on technology enhanced self-regulation and decision-making for tomorrow's medical professionals through innovative use cases practiced at the Leeds Institute of Medical Education, in the UK and the Medical School of the Aristotle University of Thessaloniki in Greece. The expected institutional and societal impacts are considered in the relevant timescales of addressing the problem and in view of forthcoming technological innovations.

Keywords: technology enhanced learning, self-regulation, scenario based learning, decision making, workplace based assessment, feedback

1 Introduction

Health can be both a driver of the European economy (through the provision of skilled jobs and good public health) and also a brake (when healthcare systems fail to deliver). With the increasing demands on healthcare services, Europe faces a health challenge due to a shortfall of healthcare professionals and the aging of the healthcare workforce. There is a clear need to train and retain more healthcare professionals [1].

The transition from medical school to clinical/community practice is a challenge both for junior doctors and medical schools. Key contributors to this challenge are associated with the significant differences and gaps between the actual requirements of clinical or community practice and the ways traditional medical schools provide skills and preparation to their students during the studies [2]. However, effective professional performance is premised not only on theoretical or conceptual knowledge, but also on tacit knowledge that could be applied to meet the requirements of specific work environments. Thus, two major goals for educational institutions are (i) to elaborate a realistic work-based placement plan and (ii) to support the students in development reflective, self-regulated learning skills throughout the university degree and beyond. Some medical schools already do this and others are learning from them, e.g. through joint educational initiatives[1]. The ultimate goal is to prepare medical students through engagement in practice, so that they grow as professionals and reflective practitioners.

Two key issues are at the heart of this problem. On one hand, there is the medical student's **self-regulation** ability which is underpinned by the use of reflection effectively to identify areas of strengths and weaknesses, set personal goals, develop strategies to attain these goals, and optimise learning and performance [3]. Relevant to this issue is the development and consumption of digital tools and relevant content. The main aim is augmenting the learning process, as well as, the students' engagement with it. On the other hand, there is the process of training medical students to acquire suitable skills for **clinical or community decision making**. Many medical schools provide students with extensive clinical clerkship in order to experience real work situations. However, there is no guarantee that students will serendipitously experience the whole range of clinical problems. Populating curricula with electronic resources of interactive character has been typical for many Institution's modernisation strategy. Quite innovatively though, some Medical Schools use the notion of Virtual Patients (VPs) [4] to maximise the value of decision-making and clinical management through scenario based learning activities (SBL), as a teaching/pedagogic method of choice, that provides students with the opportunity to work, think, and take decisions collaboratively. Some others, exploit the contemporary concept of Living Labs [5,6] to enhance even further the prospects of medical student work-placements and their empowerment through practical, hands-on uses of technology assisted healthcare services. Others have implemented a mobile learning curriculum in which mobile tools and resources enable students to collect, reflect on and share with tutors their experiences and feedback whilst on workplace based placements, as well as providing quick and easy access to relevant learning materials whenever they are needed [7, 8].

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[1] https://medhealth.leeds.ac.uk/info/843/medical_education_for_professionals/1017/mumeena

The scope of this paper is to provide a vision as to *how future workplace learning and professional development may be addressed by means of exploiting related prospective technologies and associated pedagogical models*. Linked with this notion is the timescale of addressing the problem by considering necessary research and innovation and the expected institutional and societal impacts. In the remaining of this paper, we will shape the vision. Our emphasis is placed in the synergy of two perspectives: the self-regulation challenge and the decision-making process, especially when attempting to face complex problems. While these perspectives have been explored independently, we will argue that through the effective use of technology, both perspectives can be unified to innovate medical education. Both perspectives are envisioned by, and illustrated with, the application of empowering technologies for tomorrow's medical professionals through innovative use cases practices at the Leeds Institute of Medical Education (LIME), in the UK and the Medical School of the Aristotle University of Thessaloniki (AUTH) in Greece.

2 Motivation: Digital Technologies in Medical Education

2.1 Developing and deploying digital medical resources

Following the disruptive power of the 'Empowered Consumer' notion on industry [9], we envisage technological disruption to medical education by enabling the shift to the 'empowered medical professional' who will "take control" of his/her professional development. This is not something new, but the way in which technology can provide more sophisticated support is new. This view is driven by the technology facts of connected lives [10] and the societal abundance of choice. Added to that is the ubiquitous digital access to a massive amount of data based on personal preferences and interests, especially by the young individuals (information - any place, any where, any time). Attributes for the above are technologies that are mobile, smart, global (across borders) and hands-on. Consequently, the following question requires urgent attention:

> *If the medical student (and later the medical professional) has this digital empowerment and independence, how should medical schools utilise the technology to shape novel environments for developing key skills, for providing new learning opportunities, and for creating training content?*

It is a certainly a complicated space, but there are several technological advancements that can influence the digital content development for medical training:

- Firstly, the so-called *contextual content relevance* plays a key role. This means that digital medical content needs to find learners at the right place, just-in-time and on the right platform. Using content driven by "consumer intelligence" can uplift the confidence of, and relevance to, the content consumer (the medical student/professional in this case).
- Secondly, equally important is the *analytics driven decision making*, also related to "predictive analytics". As student feedback loops continue to generate more and more data, content creators can gain a detailed and deep understanding of

the students' needs and adjust/repurpose content accordingly [11]. Furthermore, by extracting an analytical model from multiple sources of data, it would be possible to predict future behaviour or outcomes.

- Thirdly, the recent shift towards allowing students to *connect on the technical platform of their choice* opens a new dimension for the use of technology in medical education. For example, in LIME a "Bring-Your-Own-Device" mobile-enabled paradigm has been implemented to deliver medical content situated at the workplace [12, 7, 8].
- Finally, technology can allow *in-situ capturing of experience and feedback at the* workplace, to allow reflection and goal setting. In addition, virtual, augmented and mixed reality technologies are being adopted to facilitate transition across medical practice contexts[2].

The common principle behind the above technological advancements is that they *empower engagement*. Specifically, it is the action of promoting the exchange of interactions/tasks/content with the students via a range of platforms in order to keep them focused, motivated, and "connected" [12]. Linked to this, is the seeking of methods that further enrich that engagement by enabling a *more personalised and adaptive learning experience* for students in medical education which enables the creation of pedagogic value through engagement, e.g. to promote reflection and self-regulation. This is usually done in close collaboration with clinicians, academics, students, patients and carers to ensure quality and relevance [3]. In a similar vein, guiding students on how to explore open educational resource (OER) ecosystems [13] and link open (multi-type) content [14] to their envisaged learning outcomes, though not new as a concept (see for example the mEdcuator project[3]), is becoming highly important to help increase effectiveness and reduce costs.

2.2 Self-regulated work-based learning

Supporting students to take control of their own learning, reflecting on their skills/knowledge/practice/feedback and developing and enacting plans to improve is an essential aspect of medical education [7, 8. 15]. Such self-regulation skills go hand in hand with work-based activities, including placements, internships or project work, as the latter provide an excellent opportunity for reflection and action. However, simply exposing students to the workplace will not on its own equip them with self-regulation skills.

Connecting formal subject-based education and informal work-based learning remains a longstanding challenge. Providing students with access to workplace tutors/mentors to link experience to professional development has been attempted, but one-to-one mentoring is costly and not easily sustainable or scalable. The pedagogical underpinning of self-regulated learning is to actively engage students to "research what they do to learn and how well their goals are achieved by variations in their approaches to learning" [16]. This involves an iterative process where the learner goes through

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2 time.leeds.ac.uk , www.leedsmedex.ac.uk

3 www.meducator.net

phases of surveying resources, setting tasks and achieving goals, evaluating results and estimate the likely changes. Therefore, temporal traces are necessary to monitor and analyse this process [17, 18]. Mobile technologies allow capturing 'in-situ' feedback from workplace activities and exploring this feedback later for reflection. Moreover, the learner can receive individualised support for interacting with his/her assessment data to identify their strengths and weaknesses, set learning goals, and identify learning opportunities to achieve these goals.

Thus, the crucial challenge is then to support students to fully engage with the work-based experience. A possible way in which technology can be used to do this is through the use of:

- a digital system that allows for the collection of work-based placement feedback from others as well as their own reflections on their practice, and
- personalised prompts to students to use this feedback to reflect on their performance and improve their professional development planning and practice [3, 16].

2.3 Empowering clinical decision making with scenario-based learning

The best way to acquire knowledge and experience for actual clinical or community care work is for students to work through real patient scenarios. Ideally, this will be in the hospitals, in a near-patient-learning context. However, in many cases this is not practical (e.g. some contexts simply cannot be provided or properly resourced) nor scalable (enabling a vast number of students to gain experience with a diverse range of scenarios is highly costly). This can be overcome with interactive electronic scenarios in the form of virtual patients (VPs), which are increasingly recognised by the medical education community as an effective training tool for clinical reasoning [19]. VPs are also effective for learning clinical sciences and developing skills in patient management [20]. In this kind of interaction, students can explore and clinically manage the VPs, make mistakes, and learn from them. This provides practice in active management of a patient rather than passive learning. It is ideal for the challenges presented in cases where practitioners need to make rapid assessments, instantly take decisions, and prioritise efforts. Controlled trials with 'interactive' VPs have shown [21] that taking decisions, being able to virtually manage a patient, has a profound impact on recall of the correct management strategy. Moreover, emotions and memory are enhanced when scenarios embed realistic representations [22].

3 The LIME and AUTH Contexts

Experience in two medical education contexts – at the Leeds Institute of Medical Education (LIME) and Aristotle University of Thessaloniki (AUTH) – enables us to indicate opportunities and challenges for using technology in tomorrow's doctors training.

3.1 Self-regulation empowered by personalised adaptive learning companions

LIME has designed and delivers a 5-year undergraduate program leading to the degree of MBChB (Bachelor of Medicine and Bachelor of Surgery). Successful graduates provisionally register with the General Medical Council and start supervised practice of medicine. UK requirements for unsupervised practice demand a further Foundation Year program to be undertaken. A set of professional values and core themes is integrated throughout the MBChB `spiral' curriculum [23], during the first-year of which students are introduced to the core biomedical principles, body systems and themes that underpin clinical practice. This lays the groundwork for later years when this knowledge is iteratively built upon. Crucially, placements and clinical settings are an integral part of the degree, with students experiencing their first clinical placements as early as term 2 in year 1 and increasingly spending more time outside of traditional academic settings. An `entrustability' scale (from observe to supervise, initiate and then peer teach), expressing higher level of attainment/responsibility in clinical settings is one of the measures used to monitor the student's progress.

The LIME myPAL project is a strategic technology enhanced learning project that aims to provide a personalised adaptive learning companion that fosters the development of self-regulated learning skills [3, 16]. The project vision is centred around the importance of developing self-regulated learning skills and the key roles of reflection on feedback and subsequent action planning. It builds on the ubiquity of digital devices and the availability of a vast amount of student assessment and feedback data collected throughout the MBChB at Leeds. including data and feedback on both campus-based activities and work-placements. Previous research has shown clearly the great value of reflection on feedback and the positive effect it can have on learning [24], but this requires the student to actively engage and go beyond a tick-box approach to reflection. myPAL is enabling us to explore how analytics can be used to help us to identify students at risk of low engagement and then nudge them to reflect and action plan more – scaffolding their development of self-regulated learning skills.

myPAL realises the educational analogy of the so called ‘Quantified Self approach’ - personal life ubiquitous data are used to empower people to achieve self-awareness and self-management and take control of their lifestyle. Similarly to this disruptive innovation in health and well-being, myPAL aims to innovate the educational arena by providing the student with a holistic view of their rich learning data (including summative and formative feedback, workplace-based feedback and reflections, learning resource usage etc) and supporting them to reflect on this, identify patterns and plan actions to improve their learning and practice. In this way, innovative uses of learning analytics combined with interactive nudges are being designed to support students to develop self-regulation skills.

The pedagogical underpinning of myPAL lies along with refection on work practice to contextualise practice within the medical curriculum, identify strengths and weaknesses, and plan their professional development by exploiting learning opportunities and engaging in learning conversations with their workplace tutors. The traces of these electronic feedback encounters, as provided by the tutors, allow for anytime, anyplace reflections by the students. Suitable visualisations of these could support students to

attach a personal development meaning to any trace patterns and make connections between practical experience and curriculum activities. The timing of sequences of reflection activities in myPAL is also envisaged to allow a deeper interpretation and understanding of the placement activities. For example, highlighting notable patterns or associations and eliciting nudges for behaviour change. In this way, myPAL is funded as a technological innovation in learning and teachingthat is impacting the interaction with the student by: (i) fostering the contextualisation of assessment and feedback; (ii) triggering reflection to identify strengths, weakness, and possible blind spots; (iii) setting learning goals and devising personalised plan of learning activities to achieve these goals.

3.2 Living Labs and technology powered community care ecosystems

AUTH operates a 6-year undergraduate program leading to the degree of Medicine. Successful graduates provisionally register with the Panhellenic Medical Association and start supervised practice. During the last few years, the curriculum remained largely unchanged covering wide objectives, while students lacked practical methods of clinical work as noticed during the academic external assessment exercise in 2010. Recently, the School has engaged into a practical work-placement programme which was developed with a focus on community care and public health and a "hands-on new technologies for healthcare services" notion. At the same time, an elective course on "Entrepreneurship and Innovation" with a focus on social innovation was also introduced.

In 2014, AUTH founded a Living Lab in Thessaloniki, dedicated, to start with, on active and healthy ageing studies (Thess-AHALL[4]), thereby fostering the default user-centred, open innovation ecosystems based on a systematic user co-creation approach. Thess-AHALL integrates research and innovation processes in real life communities and settings by placing the elderly citizen in the core of innovation and exploiting the ability to harness the opportunities offered by new technologies contextualised by local cultures and personalised attitudes. The lab serves as a demonstration and practice space for the LLM Care ecosystem, an established self-funded initiative in technology driven elderly innovative social care [25].

The concept is that medical students may also be trained in the Living Lab, and then, during their practical two-month long internship, exploit the use of innovative social care technologies in actual work-placements. During the latter, the activities of social care achievements are recorded in the LLM Care system logs. In addition, students use simple web logs to register the weekly diaries. Reflections are finally fostered in an end-of-placement focus group discussion followed by a dedicated survey. These activities are complemented at AUTH with virtual training scenarios in form of VPs and as result of the ePBLnet project[5] . The latter has contributed to the development of human resources through the modernisation of medical education in a way that mirrors clinical practice and through the endorsement of technological developments which give the

[4] www.aha-livinglabs.com

[5] www.epblnet.eu

opportunity to future healthcare professionals to take decisions and explore the consequences of their own patient management.

4 Towards Augmented Minds

This visionary statement addresses the 'wicked challenge' of higher education to make learning more relevant to the job market and prepare medical professionals to deal with the challenges they will face in their profession, medical institutions should embark on an ambitious mission. Like any other jobs, those of the medical professionals will require higher level skills, which calls for new models for learning, such as promoting work based learning including quality traineeships, apprenticeships and dual learning models to help the transition from learning to work. Medical professionals increasingly require soft skills, like the ability to think imaginatively, develop creative solutions to complex challenges and adapt to changing circumstances and new constraints.

Digital technologies are already pioneered to address these challenges. We illustrated such technologies here: (i) workplace based learning augmented by mobile technology to support reflection and gathering of feedback & experiences, (ii) virtual patients for scenario-based learning driven by real problems, and (iii) living labs for contextualised informal learning. *Combined together*, they form the basis for the vision of **augmented minds**: digitally empowered medical professionals who use technology to enhance their learning and professional development. They will be able to take advantage of the availability of a variety of technology, personalise their learning by reflecting on their progress and identifying opportunities to learn anywhere and anytime, continuously improve in their profession.

The next major challenge is to make the technology *smart* and *seamlessly embedded* in the learning process. We envisage this to be realised through some form of *interactive contextualised nudges* informed by methods in professional coaching. They can foster critical and creative thinking for meaning making from work practice. This new kind of pedagogic model, the need for which is stressed by contemporary research in professional lifelong learning, can be shaped by advancing innovative tools and settings, like myPAL and Thess-AHALL. A combination of the cases at AUTH and LIME will couple work-placement training with technology driven innovation in doctor training, thereby addressing the skills demand.

Crucially, this will maximise work-placement training experience, and with the use of the underlying analytics will signify the role of the tutors and the institutions as they can proactively exploit nudges to foster student engagement. Put these concepts together with the co-design offered by the Living Lab training and the capacity of VPs to safely train students in decision making (aspects of thinking fast-thinking slow depending on the scenario) could potentially uplift medical education and technology enhanced learning for workplace and professional learning altogether. Developing such innovation capabilities will truly ensure the education of Tomorrows' Doctors able to deal with future complex problems, not just today's context and knowledge. The potential of technology to 'digitally empowered medical professionals' is an exciting prospect which medical schools should embrace.

This vision impacts on the individual learning of medical students, the medical institutions, but also to have a wider societal and economic impact since health underpins our economy and community. Research and innovation are rapidly changing how medicine is practised and how care is delivered, with new treatments, new technologies and new ways of working and managing conditions being introduced. This fast-paced change will continue, it is essential that healthcare professionals can embrace research, innovation and change. Equipping the future healthcare workforce with the decision making, reflexive learning and creativity skills will certainly lead to faster adoption of new innovations and improvements in healthcare service and delivery. There is perhaps also a point about the patients of now and increasing in the future, who will also be digitally empowered and so medical professionals need to be able to support patients and their carers in accessing the right information.

The 'digitally empowered medical professional' vision should be taken with caution though. There is a lot of value in the way that medical education already takes place, while new ideas are not fully developed and tested. One should be careful not to dismiss totally everything that has gone before in favour of a model that is not yet fully implemented or tested. The key challenge is to find the balance between preserving what already works and bringing innovation to address what may not be effective. We envisage various interdisciplinary projects in the following years to address this through design-based research by engaging stakeholders, researchers and developers.

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