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Many-body Approaches to Cross-level and Multidisciplinary Initiatives for Encouraging Learners into STEM from Primary to Further and Higher Education

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Abstract

With the increasing demand for STEM professionals, together with many of the current STEM professionals approaching or already gone over retiring age, there is a current shortfall which is now an urgent requirement to be addressed by Western countries as so much of activities and life in general is increasingly technology dependent. Actions that are currently being taken to address this shortfall in the UK by academic establishments, organizations and professional bodies are considered in this paper. Some of these include those actions that are directed at encouraging a better gender balance in the future as well as those involving actions to attract students to be aware of STEM from an early age to supporting women returning to the STEM profession. Parts of our research examines the learning and studying approaches adopted by some of the learners, their levels of attainment and attitude to learning to use technology and using technology to improve their learning. The paper reports on the developments and improvements from some of these initiatives and activities implemented. Some of these actions include details of competitions from primary to postgraduate students, women only training sessions, online support groups for STEM women, ranging from technical to career and social issues, and details of CAS (Computing At School) support for teachers, both face to face and online, currently with over 30,000 CAS participants. In conclusion the paper reflects on a roll out of some of these activities and potential impact on enhancing interest and uptake of STEM subjects by both the young and older learners and across diverse levels of education.

Keywords: STEM education, learning styles, women in computing, professional development, computing at school.

Introduction

Recent advances in science Technology, Engineering and Mathematics (STEM) has facilitated problem-solving, and understanding of complex systems. This has led to a move toward creating cyber infrastructure-based service systems, e-Science (Swaid, 2015). There is a need to sustain this revolution across all areas of science, engineering, and education. This requires the formation of the right type of policies, a citizenry and workforce with the knowledge and skills needed to design and deploy as well as adopt and apply these systems, tools and services over the long-term. The means to engage in this process should be available at all stages of formal and non-formal education (from primary, through secondary and lifelong), training and professional development (NSF, 2007; NSF, 2013). This must be extended to all individuals and communities at all levels and in all disciplines.

With the increasing demand for STEM (Science, Technology, Engineering and Mathematics) professionals, together with the fact that many of the current STEM professionals are approaching or already over retiring age, there is a current shortfall which presents now an urgent requirement to be addressed by Western countries, as so much of activities and life in general is increasingly technology dependent (Ross, 2016). The challenges and potential solutions to educating learners in different disciplines are important if the problems faced today in the decline of numbers of STEM professionals both in education and industry are to be adequately addressed. There two major areas of major challenges when it comes to educating STEM teachers. They include an apparent lack of ownership of process and continuity relationship between STEM tutors and students and the second one is the challenge of being overwhelmed in caring for students' educational complexities, needs and workflow.

Actions that are currently being taken to address this shortfall in the UK by academic establishments, organisations and professional bodies have been considered (Uhomoibhi and Ross , 2010, Uhomoibhi and Ross, 2013). Some of these include those actions that are directed at encouraging a better gender balance in the future as well as those involving actions to attract students to be aware of STEM from an early age and to supporting women returning to the STEM profession.

Professional Engineering Bodies

The various professional engineering bodies are actively encouraging women to assist in addressing this urgent STEM shortfall. All of the STEM professional bodies in their Codes of Conduct or of Practice include requirements to promote, diversify and encourage the maintenance of records of gender balance within their society. The majority of professional engineering bodies also are very active in reaching out to students at schools, colleges and universities.

There are a range of activities organised by professional organisations whose membership comprise individuals from the education, business and public sectors with varying levels of professional experience. This experience is brought to bear on activities of the specialist groups and regional branches. Experience is an essential element in education and has been considered and an essential one as it carries with it a rich resource for learners (Brookfield et al., 1995; Merriam, 2001). Professional organisations is seen as a melting pot that allows seamless interaction across levels, within disciplines and across sectors for deep learning to take place.

The BCS, The Chartered Institute of IT, (BCS, 2018) has a very active BCSWomen's Specialist Group that aims to provide on-line technical and more general support, in addition to face-to-face meetings, and to provide speakers as a female role models for careers events at schools, colleges and universities. Free or low-cost courses are also arranged to introduce women to coding and to up-skill existing professional women, especially those that are on extended career breaks, of say five years.

The local Branches and the international Specialist Groups of these engineering professional bodies are often very active and in supporting careers events with the hope to interest potential professionals of both genders to join the engineering industries. Examples of some of these activities are the competitions organised by the BCS e-learning Specialist Group and the BCS Green IT Specialist Group. These involve students from primary school to Higher Education, producing Power Point posters to explain their ideas for the use of IT in learning and the use of IT to improve the environment respectively. The BCS Animation and Games Development Specialist Group hold competitions to design or construct a new computer game. It is hoped that these types of competitions will raise the interest of students of all ages.

Computing At Schools

Various initiatives have been tried, including separate classes for boys and girls for technical subjects to encourage students into the STEM areas. Other initiatives have been based around encouraging computing games for all ages that are not so confrontational and are thought to be of more interest to attracting girls. A major change was introduced in many schools in the UK in 2014 with a new computing syllabus aimed at all stages from primary through to the end of secondary level of education at the age of sixteen. This introduced more problem-solving approaches. This CAS, Computing At School, (CAS, 2018) initiative was generated mainly by the BCS with the UK Government and support from the IT industry. To assist the teachers at all levels experienced “Master" teachers were trained to help other computing teachers in their geographic area. A considerable amount of free online support material has been generated, together with online support at regional physical meetings to assist the teachers. The decision to introduce this syllabus at all levels at the same date has created a constantly increasing need for preparation for the teachers at all levels to produce new or modified material each year.

Once the initial cohort has progressed from primary school through to completion of the secondary school, the teachers will then need to constantly update their material to reflect the fast-changing world of the IT. Students that are following the CAS syllabus will normally start with the Python language in primary school then progress to other languages in secondary school. When these students continue to Further Education at the age of sixteen then to Higher Education at typically eighteen years of age, there could be future problems for educational establishments with classes consisting of those with thorough computing education from the CAS scheme and those students who have not followed this syllabus. Currently many universities are not fully aware of these potential problems.

Anyone can join the CAS network at no cost. There are currently over thirty thousand members, the majority of whom are teachers but with a reasonable proportion that are currently IT professionals. There are currently CAS hubs in many counties outside the UK, including in Sweden, Germany, South Korea, Thailand, Dubai, and Qatar. Interest in the CAS approach has been expressed also by countries including Japan, US, Poland, Hungary, Belgium, Switzerland, Slovenia, Denmark, Estonia, Israel and New Zealand.

4.0 Organizations' Actions

Some organisations are very active in reaching out to students at schools, colleges and universities. Employees can be encouraged to volunteer as school governors and others as technical expert "helpers" for the teachers, to assist with the students' projects and running after school engineering clubs. Some organisations provide work experience of one or two weeks for school students, while other engineering organisations offer an Apprenticeship scheme, accepting students at sixteen years of age or for a Higher Apprenticeship, accepting students at eighteen years of age. The latter is being viewed by some as an alternative to a university degree. These schemes take longer than a conventional UK degree of usually three or four years, but the apprenticeship can also lead to a university degree as the student usually studies on a part-time basis by either attending one day each week or attending for a block of one or more weeks at a university or college. These "block" sessions can be residential, if held at a distance from the organization. The advantages for the student is that they incur no student debt through the cost of the university's course, and the student will receive a salary during the apprenticeship as well as gaining valuable experience, often in three different parts of the organisation. The organisation can gain a potential employee that has been trained in the organisation's manner of working.

Students on the four-year full-time degree, spend the third year working in an organisation. By providing this "placement year", the organisations are helping students, particularly in engineering subjects, to gain useful knowledge and an understanding of the work environment, especially in technical roles. When these students return to the university for their final year, the student often base their individual final year project on addressing a problem from that organisation. Some organisations, especially in the technical area, maintain a "graduate scheme", where students work for the organisation usually for a couple of years and receive regular training and experience in several different areas of the organisation. These graduate schemes, like the apprenticeship and placement schemes, are extremely useful in helping students to gain a range of technical experience, and helping them to choose the area for their future professional career.

Organisations can be encouraged to maintain contact with women who are taking long career breaks, such as five years, possibly to raise a family. This can be achieved by introducing a "buddy system" to link each of them with a current female employee, possibly one who has returned from an extended career break. Arrangements can be made to include these "missing" women in group technical and social activities, at little cost to the organisation. These women might, following this "buddy system" support be more willing to return, initially part-time, then full time to the organisation with few problems as their technical and organisational knowledge has been kept up to date. Due to maintaining this bonding with the organisation, the employer gains an employee that can be "work effective" often after considerably less time than a new employee with no prior knowledge of the practices and procedures of the organisation.

Survey Results

Almost every year a number of surveys are conducted concerning the numbers and roles of employees in the STEM area, identifying particularly the trends including those associated with the gender balance. The latest survey scorecard of computing professionals was published showing still only approximately 12 percentage of females in the profession of which even less are at the higher employment level. Only 19% of the digital tech workforce is female, compared to 49% across all UK jobs. Black, Asian and Ethnic Minorities (BAME) account for 15% of digital tech workers. This is significantly higher than the 10% across all UK jobs. Ethnic diversity is above UK average, yet gender diversity is significantly lower, but both fall short of being representative of the UK population. From Insight report 2018, on average 72% of UK digital tech workers are over 35, challenging the stereotype that jobs in this sector are the preserve of millennials. East London, the site of Silicon Roundabout, is the only region where the majority of digital tech workers (51%) are under 35
(Tech Nation, 2018)

The Royal Academy of Engineering reports that “Women make up 51% of the working age population, they make up only 8% of professional engineers. 6% of professional engineers are black and minority ethnic (BME) but 29% primary school children are BME” (RAEng, 2018). Studies also show that “Companies in the UK are projected to need 1.82 million additional people with engineering skills from 2012 to 2022. This means that we need to DOUBLE the number of graduates and engineering related apprentices coming out of colleges and universities (RAEng, 2016). The latest statistics just published on women in technology have implications for actions by various bodies including the governments. The serious shortfall, to meet the UK Government's recognised requirements, and needs to be addressed, not only directly by actions aimed at teachers, students from primary school to university, and also supporting STEM professionals, especially if their career has a break of several years.

Securing steady and adequate supply of employable STEM graduates is essential to meeting the needs of international business. Studies found that that 39% of businesses in the UK need more people with STEM skills and have problems recruiting, and 53% anticipate problems within the next 5 years. This situation is believed to be similar across the world. (CBI, 2014). Securing a plentiful supply of future STEM graduates is vital to fill international business needs. A Confederation of British Industry survey in 20141, found The situation globally is similar, with many of the delegates participating in this discussion reporting a shortage of STEM graduates within their own countries.

Culture and Self-Directed Learning

Culture and the ability to engage in self-directed learning both play significant roles in life and learning. In addition to seeing an individual learner as someone who is autonomous, free and growth oriented, it must be noted that that individuals are shaped by their society and culture, which have their own history and the social institutions and structures defined to a large extent the learning transaction of the individuals (Rogers, 2002). Amongst the several definitions put forward by scholars, culture remains a large and inclusive concept, which functions to improve the adaptation of members of the same group to a particular ecology, including the knowledge that people need to have in order to function effectively in their social environment (Samovar et al., 2006). The culture of a society is the glue that holds its members together through a common language, dressing, food, religion, beliefs aspirations and challenges. It is a set of learned behaviour patterns so deeply ingrained’ that we act them out in ‘unconscious and involuntary (Abdullah, 2006). Cultural values are emotion-laden, internalized assumptions, beliefs or standards that shape how we interpret our life experiences (Merriam and Mohamad, 2000) anywhere, anyhow and anytime.

Culture plays an important role in learning (Lal, 2003; Brookfield, 1995). It has the capacity to influence the learning styles of learners (Manikutty et al., 2007). It has been noted that SDL is the central concept in the study and practice of education, which goes to show that Culture and SDL are central to learning. Culture has the potential to shape the growth of SDL among learners. Learner autonomy, an important aspect of SDL (Brockett and Hiemstra, 1991; Guglielmino, 1977) is limited by what the culture allows (Rogers, 2002; Hazadiah and Faizah, 2007). STEM subjects lend themselves well to being relevant to the culture of society. With the advent and fast pace of advances in technology individuals are able to adopt a flexible approach to learning the hitherto perceived difficult concepts which can now be simulated and unpacked using computers.

Conclusion

The future dependence in the accuracy and quality of software is a critical requirement, whether considering business, environmental or safety critical systems. To ensure that there are sufficient well qualified professionals in the future, the authors feel that it is essential to increase considerably the number of engineers. To achieve this, the students, their parents and teachers need to become aware of the wide range of interesting and rewarding, both personally and financially, areas of employment in the fields of technology.

In the future, possibly more emphasis needs to be aimed at the wider public, particularly the parents, about the future opportunities. This could be achieved by raising, to the wider public as well as students, the profile of scientists such as Professor Brian Cox and to include dramas such as the television series "Howard's Way" which was based around designing and building small ships. Other routes need to be considered to generate interest in STEM to satisfy the need for future professionals.

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References

Asma A. (2006). Ke Arah Glocal, *A Publication of Malaysian Management Institute*, Shah Alam

BCS (2018). *BCS, The Chartered Institute for IT*: *To promote and advance the education and practice of computing for the benefit of the public,* available at http://www.bcs.org

Brockett, R.G. & Hiemstra, R. (1991). Self-Direction in Adult Learning: Perspectives on Theory, Research, and Practice. London and New York: Routledge

Brookfield, S. (1995), *Adult Learning: An Overview* in A. Tuinjman (1995). *International Encyclopedia of Education. Oxford*, Pergamon Press.

CAS (2018). *Computing at School*, available at http://www.computingatschool.org.uk

CBI (2014), *CBI Education and Skills survey 2014*, Confederation of British Industries, Available at http://www.cbi.org.uk/media/2807987/gateway-to-growth.pdf

Dahan, H.M. & Majid F.A. (2007), *Scaffolding Adult Education: Narratives of MalaysianPractitioners,* UPENA

Guglielmino, L. M. (1977) Development of the self-directed learning readiness scale. Unpublished doctoraldissertation. The University of Georgia, Atherns, GA.

Haron, S. (2003). Relationship Between Readiness And Facilitations Of Self-directed Learning And Academic Achievement : A Comparative Study Of Web-based Distance Learning Models Of Two Universities / By Shreen Haron. Unpublished Doctoral Thesis (PhD.)-UPM

Lal, V., (2003). *Cultural Difference and its influence on learning*, Retrieved fromhttp://community.flexiblelearning.net.au/TeachingTrainingLearners/content/article_4502.htm

Manikutty, S., N.S. Anuradha, & Hansen K. (2007). *Does culture influence learning styles in higher education*. International Journal of Learning and Change 2007 - Vol. 2, No.1 pp. 70 - 87

Merriam S. B. (2001). Andragogy and Self-Directed Learning: Pillars of Adult Learning Theory *New Directionsfor Adult and Continuing Education*, no. 89, John Wiley & Sons, Inc.

Merriam S., and Mohamad, M. (2000). *How Cultural Values Shape Learning in Older Adulthood: The Case of Malaysia,* Adult Education Quarterly.; Vol. 51. pp45-63

NSF (2007). "NSF Cyberinfrastructure Council provides its cyberinfrastructure vision for the 21 st century," 2007. Retrieved from: http://www.nsf.gov/pubs/2007/nsf0728/nsf0728.pdf

NSF (2013). "Cyberinfrastructure training, education, advancement, and mentoring for Our 21st Century Workforce (CI-TEAM),"2013. Retrieved from: http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=12782

RAEng (2016). Diversity Programme Report 2011 – 2016, Royal Academy of Engineering Reports, Available at https://www.raeng.org.uk/publications/reports/diversity-programme-report

RAEng (2018). *Diversity and inclusion in engineering measurement*, Royal Academy of Engineering Reports, Available at https://www.raeng.org.uk/publications/reports/diversity-and-inclusion-in-engineering-measurement

Rogers, A. (2002). *Teaching Adults* (3rd Ed) Buckingham, Open University Press.

Ross M (2016). *Today and Tomorrow – Can ICT assist learning and living?* Keynote address for CSEDU (Computer Supported Education) and ICT4AWE (Information and Communication Technologies for aging well and e-Health), 21-23 April 2016, Rome, Italy

Samovar, L.A., Porter, R.E., & McDaniel, E.R. (2006). *Intercultural Communication: A Reader Thomson Wadsworth*

Swaid S. (2015). " A novel strategy to improve STEM education: The E-science approach," in Wang, V. (Ed.),Encyclopedia of Education and Technology in a Changing Society.IGI Global, available at https://www.igi-global.com/chapter/a-novel-strategy-to-improve-stem-education/121898

Tech Nation (2018). *Jobs and Skills-Jobs in digital tech are on the rise*, available athttps://technation.io/insights/report-2018/jobs-and-skills

Uhomoibhi J. & Margaret, R. (2013). *"Globalisation and e-Learning: Integrating University andProfessional Qualifications for Employability and Lifelong Learning"*, The 8th International Conference on e-Learning ICEL-2013, 27-28 June, Cape Town, South Africa

Uhomoibhi J. & Ross M. (2010). *"Trends in the Development of E-Learning in Engineering and ComputingEducation"*, Proceedings of the International Conference on Engineering Education (ICEE) 2010: Engineering Education and Research for Society, July 18-22, 2010, Gliwice, Poland.

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