［論　文］

Opening the Science Curriculum to the Public to Enable Multicultural Science Learning
－Issues and Implementation Using an ICT Platform－

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Abstract

The term "Science for All" has appeared numerous times on learning modules, curricula, and also in the media in recent years. Japan is regarded as a mono-cultural society but, with the rapid aging of its society, it may need to grant residency to a greater number of foreigners in the future. Access to education for, initially, those non-Japanese and, eventually, their children born in Japan will quickly become an important issue, one which Japan should prepare for in advance. Luckily, other countries have been tackling such issues and Japan can learn from their experiences.

This paper will outline an approach to an implementation of an ICT platform which aims to provide science learning for learners of all cultural backgrounds. It will use the collective skills held by the public in its development and updates, resulting in an open source curriculum that has had input from, hopefully, all of society. Furthermore, it will allow learners to engage with science in a way that is suitable to them. The result will be a science curriculum that enables multicultural science learning implemented on an ICT platform with public involvement.

Keywords：multicultural science／ICT／open access

Introduction

How do we achieve "Science for All"? The British Science Association has set up an expert group called the "Science for All Expert Group" which has "produced a vision for a healthy science and society relationship and a substantial set of actions and recommendations which we believe will help achieve the objectives" (of Science for All) (British Science Association, 2010, p2).

They state in page two of their report that their brief is to:

1. deliver a shift in cultural awareness.
2. deliver a coordinated, wide ranging and flexible public engagement framework.
3. achieve greater acknowledgement of public engagement activity.
4. ensure public perspectives are sought.

From this, two keywords may be taken, culture and public. The relationship of science to culture, and the role of the public are being focused on as the Science for All Expert Group focuses on their brief, a brief which includes the goal of 'Inclusive Science Education'. To be inclusive, as many people as possible should be included in science, bringing us to include the public as either learners, contributors or both. Furthermore, to be truly inclusive, the various cultures in the country need to be taken into account. Reiss (2004, p9) tells us that "all science is set in a cultural milieu", which means that, without culture, science will cease to have a setting. This also can lead to the conclusion that, as there are various cultures, there are also various sciences or, at least, various views of science. A number of researchers call for us to find a way to support such various cultures and sciences, such as Tobin calling for teachers to create "multicultural communities" where "diversity is catered for" (Tobin, 2004, p186). However, not all researchers agree with this. Whitelegg and Smidt (2009, p14) tell us that some advocate a view that all reality is socially constructed, while others (referred to as 'hard line scientists') think of science as being completely asocial. I find myself agreeing with Siegel (2002, p809) who sees Western Modern Science (WMS) as superior to 'ethnic sciences' as all of us, regardless of background would, I believe, benefit from a knowledge of WMS as it is the foundation of many economic activities both nationally and globally and, therefore, brings with it a high chance of employment. Jenkins (2004, p 14) tells us that a citizen who wishes to engage seriously (with society) "has to learn some of the relevant science". However, while I agree with the above researchers, I feel that the teaching of science could benefit from taking into account the cultural background of the learners. Fensham (2004) talks about the conservatism and clear opposition of a significant number of professional scientists to using what Jenkins (added: 2009, February 28) refers to as "unscientific models" in education. Yet, could the path to learning science not use some of these "unscientific models" if it eventually leads to a multicultural population educated in science? Collins' (2000, p169) statement that "present practice teaches science for the benefit of potential scientists, rather than the vast majority" backs this up.

So, how can we enable multicultural science learning? One method could be to use ICT in order to facilitate that learning, especially in a country with good internet and ICT infrastructure. Not all researchers agree with using ICT, for example Poole (2001, p213) says that "technology is not an alternative to learning how to measure variables with conventional instruments." However, while that may have been true in the past, I think that (computer) technology has now become a conventional instrument to many, making it useful for doing and learning science. Holliman and Ross (2011, p25) tells us that "it is essential to include examples of ICT in science education to promote authentic learning". It could be that, as ICT has become so widespread, we may end up reversing that statement with ICT becoming the main way of teaching (science), and us feeling it essential to include examples of traditional teaching from time to time. Linn (in Holliman and Ross, 2011, p39) introduces three trends of ICT development:

1. The targeting of ICT for specific audiences;
2. The increasing potential for customization;
3. Increasing opportunities for collaboration.

While point three is to be welcomed, points one and two are worrisome. Instead of targeting specific audiences, resulting in increased customization, I feel that we should be trying to identify ways to produce an ICT-based teaching method which is suitable for as many people as possible. Holliman and Ross (2011, p69) comments that "designers of educational multimedia should aim to ensure that materials are accessible to a wide range of learners".

Discussion

We are told in Holliman and Ross (2011, p15) that "communications technology has the potential to extend learning communities beyond the confines of the classroom, therefore potentially introducing new 'experts' to the learning environment". The "confines of the classroom" may be meant in a physical way, but it could also be taken in a psychological or cultural way. Tobin (2004, p185) uses the word "symbolic violence" to describe the feeling of being misplaced within a community and devalued for

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one's cultural artefacts. Much of this symbolic violence occurs in the classroom, such as teaching in English when it isn't the native tongue of the students (Tobin, 2004, p185), and being forced to study only WMS, often due to the lack of enthusiasm, knowledge and/or confidence among science teachers for utilizing or coming up with investigations using or based on indigenous (non-mainstream) activities. Spencer (1996) is quoted in Whitelegg and Smidt (2009, p20) as saying that "it is relatively easy to come up with investigations based on indigenous (or non-WMS) activities" but that "it is much harder to engender enthusiasm and confidence amongst science teachers for such an approach."

The limitations of the classroom may have resulted in turning away many learners from science, instead of facilitating a real engagement with it. Cerini (in Thomas and Banks, 2009) said students most commonly used the words "useful, relevant and interesting" with regard to what they are looking for out of science. However, the sometimes slow and sometimes fast pace of science classes make it difficult to satisfy those three key words for students. This is not the fault of teachers; it is just a fact of life that if we get 30 students together in a classroom then it will often be impossible to satisfy all of the students' needs at once. Shuell (1988) says that "learning is constructive, active and cumulative" and that "it is done over time and is goal oriented". Goals will be different depending on the needs and maturity of each student. Bjorklund (2007) argues that, in the case of youths, "the time of growth and discovery should not be rushed". I agree as I think it is impossible to reasonably contemplate rushing when we do not know how much time each youth needs in the first place.

The quote at the beginning of this discussion section also tells us that ICT can introduce "new 'experts' to the learning environment" (Holliman and Ross, 2011, p15). I would like to see the public getting involved as those experts. In a diverse, multicultural society, it is the public who have first-hand experience of such diversity. If the public could become involved, the science curriculum would have a greater potential of reducing symbolic violence experienced by many students in this multicultural society. Some may be critical of allowing the public to interfere with the curriculum as the changes made would depend not only on knowledge, but also on cultural experience, introducing a new variable which may result in a less standard curriculum. However, this result feared by those critics may be what some other researchers are calling for. Chin et al. (2002) called for a differentiated curriculum and went on to claim that a feeling of belonging and competence and a transparency of process can lead to the student becoming encultured into the practice of science. If a member of the public who understands your culture is involved in creating your science curriculum, then it more likely that you will feel a greater sense of belonging. On the other hand, however, it must be remembered that removing all possibility of symbolic violence from the curriculum might not be advantageous as we need to remember that, eventually, the students will be expected to use their knowledge in the workplace and in society in general. It is there that they will surely encounter some symbolic violence and, therefore, they will need to have some experience (in the safe environment of school) of such problems in order to be able to deal with them in the real world.

Aikenhead, in the first page of the teacher's guide to the Rekindling Traditions material (Aikenhead, 2000, p1) tells us that an "important feature is the community's involvement in helping decide what is worth learning in science." The knowledge the community gives to the curriculum is a great asset, even if it may not all be WMS. It results in students having the ability to think in a more flexible way which can lead to new scientific knowledge

being produced in the future. Aikenhead (2000, p6) writes that "the flexibility to move back and forth between cultures is a definite asset " and "Aboriginal knowledge and languages are treated as an asset in the science classroom". The goal of Aikenhead's work was to include Aboriginal knowledge in the science curriculum in Canada. While the situation of Canada may be simple to understand, we have a lot to learn from his work. However, we must not forget the overriding importance of WMS in our quest to include other ethic sciences. Eber Hampton (1995, pp. 19-41) gives us his twelve standards of education, the twelfth one being Transformation - "The (non-White) graduates of our schools must not only be able to survive in a White dominated society, they must contribute to the change of that society." I believe he means White as having a cultural background of WMS. Responsible educators will prepare students for the society in which they will live and work, so an ultimate goal must be that of teaching WMS to all. Siegel (2002), in Whitelegg and Smidt (2009, p18) says that "an honest universalist definition of science is not incompatible with multiculturalism" and so there is a place for IK (indigenous knowledge) in the school curriculum. However, he views WMS as a better science, in that "it has produced a deeper understanding of the world" (Siegel, 2002, p 809). On the other hand, WMS has a lot to gain from including other ethnic sciences along the learning path along which students are led. Ogawa (1995) in Whitelegg and Smidt (2009, p17) writes that, in the process of students constructing their knowledge of WMS, they "need to work through both individual and indigenous science understandings". Cobern and Loving (2001, p209) say that including TEK (traditional ecological knowledge) and IK into the Standard account would be a 'pyrrhic victory for indigenous knowledge'. I do not agree with this as learning should not be a matter of "what (geographical) knowledge wins", rather it should be "how are we best serving the future needs of the students".

Aikenhead also discusses evaluation in his research. He advocates using checklists as a positive approach to assessment which record what has been done and " not a judgement on how well something was done". I tend to agree with this as I feel that we cannot expect students to always do something well when they do not have experience of it, but that the doing of science will, eventually, lead to it being done better. Therefore, having students do (and frequently do) science may be more important than how well they do it, at least in during their initial years, i.e. their years in compulsory education. The problem with emphasizing how well students do science has led to students narrowing their focus to try and get a high score on exams. Nott and Wellington's (1999) work points out that this is not only true for students, but also for teachers in that teachers will try to maximise their students' scores when those scores are used as a teaching performance indicator. They say that teachers and students (at all levels) are aware of performance indicators and will "learn to play the game in ways that contradict (the) good intentions". Peacock (2002) backs this up and indicates that there is a danger of 'science for all' becoming 'scores for all'.

How can the needs of the students of today be best served, bearing in mind the challenges I have outlined above? I feel that the answer could be in an ICT-based model of education. As I have pointed out, the vast majority of have access to ICT and, with that, access to online learning resources. However, I think that many of these resources are flawed in that they seem to have gone through a similar production process of planning, design, testing, etc... and eventually a final product being released. Once the final product is released, it may not change very much until the end of its useful life. There may be updates to correct bugs, etc, but the core product does not usually change. Examples of such software (although not science learning software) are the Microsoft operating systems, the most recent at the time of writing being Windows 8. Those who are running an older Microsoft operating system (such as Windows 7) will not have the features of the new operating system available to them, and will have to pay to upgrade to the new version. This results in fragmentation of the user base into early adopters, pragmatists, conservatives, and laggards (Sink, 2008, May 21). I believe that this fragmentation is also happening in science where ICT is being used by teachers, parents and students for science learning. Recently, however, with the advent of programs held/stored on the world wide web, or in "the cloud", rather than on the hard disk of the user's machine, it has become easier to keep users updated with the most recent versions of programs. Furthermore, the traditional way of creating ICT-based content is also changing, at least in the mainstream (or some would say the fringes are moving into the mainstream). Instead of creating a program, using it for a period of time, then discarding it in favour of a newer version, the program can now be continuously improved and the result easily distributed. However, those doing the improvement would be not only the programmers and the scientists directly in this papers vision of public involvement, not only those professionally involved in the project but also the public in general, even the learners themselves could be involved.

There are a number of precedents for such a software development idea, one of the best known possibly being the Linux operating system. With Linux, "the underlying source code may be used, modified, and distributed-commercially or non-commercially-by anyone" (Linux, ed. 2012, September 23, 08:33). This concept, together with applications that live offsite (of the learner), on the Internet, make it possible for all of the public to be involved in the creation of ICT for science. If a multicultural public were to get involved in such a project, then there is a high probability that the resulting material would include materials that help to communicate with multicultural learners. Oliver (2004, p130) tells us that "studies that do not communicate effectively with an audience are worthless". I believe that having the learners' own communities involved in the creation of science learning material would enhance effective communication. The software created would be adapted by various communities, hopefully creating a balance that would adapt itself to each learner's needs, which could include links to discussions from other cultures, and reflect on the differences and similarities of content made by various contributors. Laurillard (2004, p29) says that complex learning is "an iterative conversation involving four key processes: discursive, interactive, adaptive, and reflective". Having students go through material written by various contributors would create an iterative conversation in their minds. The online nature of the ICT material would make it easier to be interactive, not only in a learner-software way, but also in a learner-learner way as there would be many learners connected to the software at once. This fact could be used by the (outline) designers in promoting interaction and debate between users, maybe requiring such debate to happen in order for the user to progress to the next stage.

The use of such interactive, online ICT may remove the need for a teacher if it provides what the teacher was providing in traditional education, some will claim. Laurillard (2004, p30) says that "a good teaching strategy will pre-empt what the learner needs. Without a teacher present, the educational media themselves must provide what is missing". I take this to mean that the media can provide what is missing, if designed well. However, I believe that a teacher is still necessary as a coordinator and provider of extra information (and to decide who needs that information and when), and as a enabler of discourse, whether online or in the physical world.

Feldman et al (2000, p135) warn us about

technology. We now have a myriad of choices, and may become overwhelmed by the choices we have, or may decide on using a certain technology just because others are doing so. Their research makes the statement that "technology opens doors; educators need to be prudent in their choices about which doors to enter." This, I believe, means that we need as many experts as possible, at every stage, in order to make sure the doors we choose to open are correct. The body of knowledge held by the public, the time that they collectively have to put into projects of interest to them, and the cost efficiency resulting from using volunteers in wider society would help in choosing a correct way forward for science education.

Some science educators and practitioners may worry about how the public's ability to understand the body of knowledge of science, or may doubt the validity of the idea of multicultural science in teaching. One such person may be the Nobel Laureate, Professor Ledermann for whom, according to Jenkins (2001, p17) "scientific knowledge is true, objective and universal. Any suggestion of ... multicultural science would be a nonsense". Fensham (2000, p157), on the other hand, advocates a "shift from science as a body of knowledge to science as a way of knowing". This indicates to me that we need to know about the ways of knowing that others use - by learning about other cultures and their science. For this reason, I think that all students will benefit by having multicultural science in their curriculum. However, as I wrote earlier, if we think that WMS is the science that students need to understand now and into the future (and I believe so), students need to be ultimately aware of that and realize that it is the goal of the curriculum, and, therefore, a goal of the government and nation that WMS will be understood and internalized by the population to a level that will help not only the students in their daily lives, but will aid the nation as a whole to have a stronger economic and social structure. Aikenhead (2000, p 16) has found that "students compartmentalize school science in their minds", telling us that students already seem to know that difference between 'ethnic science' and the science they are ultimately expected to learn, WMS. Lowe (1995, p665), based on his research in the Solomon Island, concluded that "to compartmentalize the world into domains, each with an interpretive framework [Western science versus magic], is not a perversity but an effective survival technique." In other words, it is a good thing that students compartmentalize their science knowledge, and such separation should be encouraged. This is something that ICT can also help with. Going too much into the core design of an ICT program would go beyond the scope of this paper, but I will explain a little of the concept. ICT can be used for various purposes, with Mansel & When (1998) in Foundation Partnership (2006, p 10) stating over 60 such purposes, under three headings. One of the uses of ICT is the gaming industry. Looking at computer-based gaming in one of its more simpler forms, challenges (or difficulty of challenges) are often divided into areas of levels. I think this concept can be used in aiding the compartmentalization of science, as well as reinforcing the importance of the science that the nation wants to ultimately teach. For example, the ethnic sciences could be at an easier area or level, with WMS at a higher level (whether it is regarded as more difficult or not). This would have the advantage of all students learning ethnic sciences before moving on to WMS, at each topic. MacIvor (1995, p74, p88) tells us that it is important that students learn multicultural science as well as WMS as, while "areas of economic development and health care require community expertise in science and technology", ethnic science must not be ignored as "conventional science must be presented as a way, not the way, of contemplating the universe". This plurality of science is not only important for ethnic groups, but for all students as those not from a minority group or a non-WMS based culture may, in the future, work in a community where WMS is not the only science. Using ICT in such a way as described above may make it easier to design a science curriculum suitable for all students.

Barriers to learning science exist. Whitelegg and Smidt (2009, p23) tell us that "language plays an important role in allowing learners to generate a shared understanding", and Forster (2003, p10) asks us to choose resources which "incorporate the language needs of multilingual pupils in lesson planning". Giving students the language support they need is not an easy task for teachers, most of whom are not multilingual themselves. This is another advantage of using ICT and allowing the public to contribute the content of the ICT-based curriculum. With ICT, various language versions of the content can be created which could then be chosen from by the pupils, parents and teachers. The content (language translations) could be provided by experts, including the public who use the language. A very simple example of this is the Google Translation Tool found at http://translate.google.co.uk/, which not only gives a translation of specified content, but also invites the public to submit more accurate translations, resulting in a more sophisticated level of translation over time. The ICT-based science curriculum could use a similar idea resulting in multilingual content that would serve the needs of a multilingual society.

Brickhouse (2001, p6) tells us that the identity of the students are important to them, yet goes on to lament that "student identities and the communities to which they belong and aspire to belong to are not adequately considered." This is backed up by Hodson (1998, pp112-113) when he says that "who we are or who we believe ourselves to be or aspire to be determines what we pay attention to and what we seek to learn." How can an ICT based curriculum help with this problem? The use of a virtual world where learning takes place, in which students could choose/create their own avatars/alternate personalities may help students to become more involved in science. In real life classrooms, students may be too aware of impressing their peers which can even lead to those who are interested in science hiding such interest in class. In a virtual world, students may not need to build such barriers or, if they feel they need such barriers, they could have multiple avatars allowing at least one of them (part of their personality) to be engaged with science. In other words, the use of ICT may help them to limit the barriers that students build in traditional education.

As for the use of examinations in learning science, ti seems that the presence of examinations causes problems such as students ignoring content that they don't see as central to the (examinable) syllabus resulting in taking a blinkered approach to a subject (Whitelegg and Smidt, 2009, p32). The course study material (Whitelegg and Smidt, 2009, p31) also points out that some have "difficulty in recognising the existence of a real-life context in the material, and choose to ignore the context for fear of wasting time". The ICT-based material could give such students the option of skipping past some material. However, for reasons stated earlier, I believe that students can benefit from learning knowledge coming at it from various angles. I have argued for using checklist earlier in the discussion, but I would like to also put forward an enhanced version of this in the possibility of using, say, (time spent online * amount of material covered (checklists) * number/quality of scientific theories (guesses) put forward), as a way of evaluation. It could end up being quite complicated and time consuming, but computers are good at doing complex tasks in a time efficient manner. An alternative could be to use self-evaluation, suggested by Forster (2003, p10).

Finally, I would like to comment on cost. Such an open-source (or open-knowledge) ICT-based science curriculum would cost a lot of money, some

(especially the government/tax payers) might argue. This could be true but it could save money in the long-run, an idea embraced by the city of Munich in Germany (Hillenius, 2012, January 6) and other cites who spent an initial amount setting up a system suitable to their needs, and are now realizing cost savings and expect to continue to save money while also keeping their systems up-to-date.

Conclusion

This paper has argued for the public to become involved in the science curriculum, in order that their knowledge become part of the science taught. As multicultural diversity becomes more evident, the need to have a curriculum that caters for that diversity grows. Using the public's knowledge could bring such diversity into the curriculum resulting in the students becoming more accepting of the science that is being taught to them. A way of allowing the public to bring their knowledge to the curriculum would be to create an ICT platform to which the public would have access, allowing them to interact with and influence the curriculum being created.

The resultant ICT-based science curriculum would have other advantages. There is a problem with the current science curriculum in that some students focus only on the examinable component and ignore the rest to increase what they may view as "efficiency of learning". However, I do not believe that the nation wants a population who are only capable of passing examinations based on limited content, the goal should be to produce people capable of making sense of science in order to use it. Tobin (2000, p187) implies that the science course shouldn't give all the answers, it should just be a guide and that "responsibility for making sense was my own". This points to a curriculum that contains tools to aid making sense as being an effective science course, instead of offering a course that is just geared toward the passing of examinations.

Using ICT as a main method of science education will also tackle the problem of symbolic violence, which makes people feel that their own culture is being devalued. The students will be able to come into contact with their own culture through the ICT platform. However, the main goal of the course should be the learning of the science that will be of most benefit to the individual and to the nation. In other words, a knowledge of Western Modern Science should be the ultimate goal of any science curriculum regardless of how multicultural its audience is. It is inevitable that some level of symbolic violence will occur, and I believe that this is a good thing. We cannot hide such realities from our youth during their school age days only to have them experience a larger shock when they enter a company upon employment, which will often be less forgiving and patient than school.

Building an ICT platform for teaching and learning science that is open to all experts to update and improve has a number of easily realizable benefits, such as lower cost over the long run, leveraging the knowledge of one community by bringing it to the whole nation, allowing students to study at a time suitable to them and in their own language, and even giving students and their parents a chance to reflect on the contents of what they are studying. It also brings a chance to reform the current evaluation-heavy methods, possibly bringing with it a refocus on what should be important in the curriculum (interest in the subject for itself rather than for points). Examinations can be regarded as an impediment to learning as, between preparation, mock exams and the actual examinations, they can take weeks or months from school time which could have been used to learn and experience more science. A different way of evaluation could result in a more efficient curriculum, and ICT offers a way to automate that evaluation.

Using ICT as a multi-level science teaching system, which is updatable by any member of the public (there will have to be some sort of checks and balances, such as the ones Wikipedia uses, for example), will make the teaching and learning of science more engaging and remove a lot of the problems with the current methodology, such as how to teach a set of goals to a multicultural society. Although we may never satisfy all of the students (maybe in the same way that you can never get full employment even in a time of rapid economic expansion - some people simply will not choose to take part) as Bauer (1992) reminds us that "widespread scientific literacy is an impossible illusion", I feel that an ICT-based science platform will bring more students into the exciting world of science than ever before. Desforges (2000, p12) tells us that "the challenge that faces us is in making best use of current knowledge about learning is that of knowledge transformation - how to convert knowledge about learning into effective practices of educators ... or of integrated learning systems". An ICT integrated learning system could be one that best meets that challenge.

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