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Book Section

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Introducing online media for informal and formal science learning

The past thirty-five years have seen an unprecedented period of growth in the development and use of online media for informal and formal science learning. These are educational media where the computational power of computers and the interconnectedness of communications technology converge. As such, these are media that are networked, e.g. via the Internet, intranets or Short Message Service (SMS). In simple technical terms, networking requires interconnectedness and interoperability between computing devices that can be located in multiple locations and different time zones. This involves digital information that can be efficiently stored, searched for, and then retrieved and shared.

Developments with online media have profound implications for the accessibility of all areas of knowledge, not least for informal and formal science learning. Online digital information, such as school intranet pages, can now be ‘retrieved’ from a number of geographically distributed locations via a uniform resource identifier (URI; a codified address that points to a resource on the World Wide Web). This information is sent to the user, such as a teacher, parent or guardian, school-age pupil, university student or informal learner, via a network. Applications (such as a web browser) hosted on compatible devices (including personal computers, personal digital assistants (PDAs), and mobile phones) then ‘read’ and ‘reformat’ this digital content, e.g. the title of the school intranet page always goes in the middle at the top; the accessibility options directly underneath, left-aligned; and so on).

This entry provides an initial definition of online media for informal and formal science learning. Three key trends in the current (2012) digital landscape will then be outlined: media convergence; accessibility; and collaboration and participation. The entry will draw on examples to illustrate some of the concepts being used to analyse and describe educational media and their uses in formal and informal science learning.

There is one note of caution. Educational media can be sold as commercial products that are developed and promoted within a competitive marketplace. It follows that, as a prospective consumer, citizen and learner, the reader needs to retain a critical attitude when assessing the relative merits of educational media.

Finally, for this introduction at least, the examples discussed in this entry are necessarily small in number, and they are only briefly described. What follows is an attempt to map what is a rapidly developing landscape, technologically, socially, economically, politically, legally and culturally. No entry that discusses online media could ever claim to be future proof. It will be up to the reader to apply these ideas, seek out new ones, locate additional examples, and critically engage with relevant academic literature.

Media convergence and the pervasive and ubiquitous nature of digital technologies

Convergence is a significant trend that has considerable relevance for how online media and educational resources are accessed and used by formal and informal science learners. In a technological sense, media convergence is all about integration and inter-operability; the coming together of computing networks, information and communication technologies, and digital forms of information that are inherently adaptable, delivered via 'intelligent' platforms, applications and devices. From an end user perspective (e.g. those seeking to learn new skills, competencies and scientific knowledge with the aim of applying this learning through online conversations, participation and collaborative contributions), media convergence involves digital technologies that encode and decode multiple streams of (in this case) science content. This can involve: (linked and aggregated) text; (galleries of) still images with the opportunity to upload and tag further images; moving pictures (such as a virtual field trip); digital simulations; self-pacing interactive tutorials (that can be structured to provide automated feedback, advice or comments); sounds; music; science-based computer games; access to remote experiments or equipment; opportunities to input and analyze data ‘on the move’; or any combination thereof. This content is mediated through one or more devices and platforms of the end user’s choosing, such as a mobile phone, tablet, lap-top, desktop computer or personal digital assistant (PDA). These media can then be customized and consumed ‘automatically’ via feeds that match the user’s personalized profile on the device(s) of their choice.

As a result of the convergence of computers with communications technologies, teachers, parents or guardians and informal and formal learners with network access have opportunities to teach and learn about scientific information that is relevant and useful to them, wherever and whenever they are, and on an increasing range of computing devices. To illustrate the point imagine an idealised (and simplified) scenario where a university student (let’s call him Fred) is on his way to an astronomy lecture on a Monday morning. Fred travels on the bus from his home to the campus watching (and listening through headphones) to an archived television show about astronomy on his smart phone. He checks the website associated with the television series and texts an answer to a competition announced during the episode as entries close at lunchtime that day. On the same journey Fred responds to a text message from a fellow student asking him to send them details of where the lecture will be archived as they are unwell and can’t attend. Fred gets to the lecture hall and checks his emails before the lecture starts. As the lecture finishes he tweets details of an open access repository where one of the academic papers that the lecturer recommends is hosted. After the lecture, he goes to the university library where he checks the discussion forums of a citizen science astronomy project that he has been contributing to. This is all achieved through a networked 'post-desktop' computing device called a smart phone, but without what we used to think of as a phone call being made. This is pervasive, ubiquitous, personalised and mobile computing where the distinction between formal and informal learning is blurred and where the student—Fred—is both learning about and contributing to astronomy within the course of a couple of hours, all of which is mixed in with leisure activities.

Of course, to become pervasive and ubiquitous digital hardware, tools and technologies have to be flexible, adaptable, intuitive and useful. Fred provides us with just one example of this. The widespread adoption of these technologies emphasizes the point. These technologies are profoundly social, and have been designed with a good range of uses, and users in mind.

It should come as no surprise, given the example described above, that the processes that facilitate media convergence are shaped by social practices and cultural values, and vice versa. The success of online media is reflected in the changes in how people access and use information, and by the blurring, in places, of the distinction between some aspects of formal and informal learning. We use digital technologies to learn about the sciences, politics, sport, and so on, whilst also contributing, through the use of these technologies, to the public discourse about these subjects. Where once people had opportunities to collate and filter scientific information via various 'traditional' communication channels, such as textbooks, printed encyclopedias and science documentaries on television, now digital technologies are also playing an important role. In effect, well-designed educational media enable different routes to learning that can combine in powerful ways, e.g. through narrative, interactive, adaptive, communicative and productive forms. Indeed, the reader is contributing to this trend by reading this entry in an online encyclopedia and accessing other related content through hyperlinks. Furthermore, if there is a wish to extend, revise or delete this entry, some media forms (e.g. Wikipedia) would allow the reader to do this, thus extending the learning experience.

Accessibility: Open and easy access to educational resources and scientific information

The second theme that we consider in this entry is accessibility. This broad theme can be sub-divided into at least two important sub-themes:

- open and easy access to scientific information;
- accessibility of educational resources to ensure that they are designed for end-users with different needs.

Open and easy access to scientific information

Routine and continued access to reliable and credible scientific knowledge (in conjunction with the skills and competencies to filter, analyse and respond to it), is crucial for informal and formal science learning. Concepts such as the 'digital divide' illustrate that a lack of routine access to information, scientific or otherwise, can reinforce pre-existing structural inequalities and hamper science learning.

Access to scientific information can be influenced by a number of factors, particularly financial constraints, which can be compounded by the fact that one piece of hardware is rarely considered to be sufficient in the digital age. Furthermore, hardware, software and network infrastructure need to be upgraded over time, adding to the overall financial cost of accessing scientific information. In addition to financial considerations, the ability to connect through secure, networked infrastructure is vital to ensure that users can access educational resources with confidence and share data and information quickly and effectively.

However, financial constraints are only one hurdle, and the proliferation of digital forms of knowledge requires skills (and continued training) in order to effectively navigate through the digital ecosystem. In other words, formal and informal learners need to develop systematic information literacy skills that enable them to sort the "wheat from the chaff"; and to be able to assess and respond to information and resources that are considered credible and reliable. This can be a particular challenge for informal science learners if they have little or no formal training in how to systematically source credible scientific information, whilst formal learners need support and study time to develop, practice and demonstrate these skills.

Another important issue that has been the subject of much attention, is the denial of access to resources that can be used for educational purposes because the content is not generally available for public consumption, e.g. because it is behind a subscription pay wall. Developments with open educational resources, open access to research papers, and open datasets provide alternative routes to content that can be used for educational purposes. Typically, open educational resources are made available free of charge to the user under licenses that promote re-use, and sometimes re-versioning, but with certain conditions attached, e.g. a requirement that the resources are not re-sold for commercial purposes.

Open educational resources have become hugely popular. Open Learn—Learning Space, for example, a repository of open educational resources developed by the UK's Open University, has been used by over 21 million unique visitors from 2006 to 2012, whilst the Open University resources on iTunes U have generated over 58 million downloads from 2008-2012. This wider trend in making educational content freely available is illustrated by the emergence of Massive Open Online Courses (MOOCs). MOOCs provide informal learners with access to educational content, but without having to formally register for a course. These developments have led to discussions about the role and purposes of higher education institutions. This is illustrated by a disaggregation of the functions that universities and lecturers provide for students: content in the form of open educational resources; support, which can be provided by lecturers, and/or by peer learners; and assessment and accreditation, two functions which may be relevant only for registered learners.

Accessibility of educational media and resources

Open and easy access to scientific information takes on another dimension when we consider users with special educational needs. Ensuring that users with different needs can access and use forms of online media, either directly or through the use of enabling technologies, requires a more inclusive and participatory design process.

'Design for all' encapsulates this approach. This approach has benefits for all users because the resulting hardware, tools, technologies and resources will be more adaptable and flexible, thus facilitating user customization. All learners can benefit from well-designed educational resources, and a user-centred approach to design greatly improves the chances that end users will be able to access the same or equivalent information. In practice, accessibility issues need to be considered at each stage of the design process: initial design and planning; asset creation; asset compilation; and media output. A combination of formative and summative evaluation, involving users with different needs, should inform each stage of the design process. The information gleaned through this user-focused design process can then inform the advice and guidance that is provided to prospective learners before they begin their study, e.g. in identifying core versus optional content, requirements, activities and assessments.

Developments with digital technologies have helped to automate some aspects of production processes, particularly around text-based resources. For example, digital information can now be rendered in multiple forms. The same text can be printed, rendered as a series of linked web pages, and 'screen-read' as spoken word. Resources should also be designed to allow users to decide which font size and text/background contrast they find easiest to read. These developments provide technological solutions that make the same content available in multiple forms.

Resources should also be checked to ensure that they connect effectively with different enabling technologies (e.g. screen magnifiers, screen readers and speech synthesizers). And there are other routine procedures that producers of educational media should make available, including the production of screen-readable transcripts for audio and audio-visual resources, keyboard accessible navigation of web pages (including keystroke alternatives to using a mouse), and the routine provision of alternative text explanations for images.

Collaboration and participation: the contribution of online citizen science initiatives

The third and final theme to be considered in this entry is collaboration and participation. After a brief introduction to ideas about citizen science projects that are at least partly conducted online., a typology of activities is offered for these increasingly popular activities to demonstrate the different levels of collaboration and participation that informal and formal science learners experience.

What is (online) citizen science?

Citizen science is a form of research collaboration involving both scientists and members of the public. Participants engage with scientific research projects to address authentic scientific research questions. Citizen science projects have a history that dates back at least a century, e.g. to the Christmas Bird Count, which was first organised in 1900 by the Audubon Society in the USA. Participants who engage with citizen science projects are given opportunities to learn about aspects of scientific research, whilst also contributing and collaborating in various ways.

Online media have enabled the development of citizen science projects where data can be collected, collated, assessed and analyzed using digital tools and technologies. These projects make it possible for interested citizens (who may also consider themselves to be informal and formal learners) to participate in scientific research that is mediated by technology. They can participate within the comfort of their own home, on a field trip, and/or in a school classroom; over the summer holidays, as part of an extra-curricular science club, or within scheduled science lessons.

Participants can conduct a range of tasks, e.g. collecting and submitting data, and/or analysing data that has been collected by others. A number of online citizen science projects have also developed resources for learning. Zooninverse, for example, has developed a number of educational resources that support activities within informal and formal science learning environments.

Online citizen science projects can be classified into at least three types: distributed computing projects; distributed thinking projects; and scientific discovery games.

Distributed computing projects

Distributed computing projects represent the earliest form of online citizen science. These projects were developed in response to the large amounts of data produced by projects, such as SETI (Search for Extra-Terrestrial Intelligence). In this type of activity, project organisers invite networked users to volunteer part of their computer's processing capacity for the analysis of data. Initially potential participants (e.g. citizens with a general interest in the search for extra-terrestrial life) access information about the distributed computing project and the related science from the project website. Should they want to become more involved participants download the project software, usually to a desktop computer or games console. That networked computing device will automatically download and analyse small packages of data using the project software, then returning the completed work units to the original project server.

The level of interaction and participation on the part of the citizen scientists is relatively limited. However, participants in distributed computing projects have opportunities to learn about the project and its methodology, and to offer resources in support on this venture. But, due to the automated nature of the analytical procedures, the levels of interaction and collaboration beyond this are limited. Participants can interact in other ways though, e.g. through online forums where they are provided with opportunities to discuss topics of interest with other citizen scientists and/or the project scientists.

Distributed thinking projects

Distributed thinking projects typically involve classification tasks and observational skills that cannot easily be undertaken by computers, such as pattern recognition tasks. Participant contribution is likely to begin in the same way as distributed computing projects, e.g. by learning about the research questions and methodology from the project websites, etc. Those who go on to register on distributed thinking projects will be required to contribute on a more active, cognitive level than for distributed computing projects.

For distributed thinking projects, participants are likely to need some level of training in the required analytical tasks, e.g. engaging in learning through online tutorials. And, as with any scientific research project, due consideration must be paid to the potential for error in the analysis conducted by all participants. In some distributed thinking projects this is minimised by giving numerous citizen scientists the same task. It is worth noting, therefore, that the results obtained by citizen scientists in these types of projects are generally comparable to those obtained by professional scientists.

One of the most popular examples of a distributed thinking project is GalaxyZoo, where hundreds of thousands of images of galaxies have been classified by online citizen scientists. GalaxyZoo participants have been instrumental in several important discoveries, for example, the discovery of a new type of galaxy, and have also appeared as co-authors on academic papers.

As with other types of citizen science initiatives distributed thinking projects can lead to the emergence online communities and collective identities, e.g. Galaxy Zoo participants refer to themselves as 'Zooites'. These communities often emerge entirely through online interaction where participants share information concerning the scientific aims of the project, information relating to the background science, and technical questions relating to data analysis or the downloading of software.

Distributed thinking projects have developed to the point where this conceptual idea has developed beyond single projects. For example, the success of GalaxyZoo has inspired the development of a number of distributed thinking projects within the umbrella project known as 'the Zooniverse', including (among others) WhaleFM, where participants help to track whale populations by identifying distinct whale song; Planethunters, in which participants look for extra-solar planets; and Seafloor Explorer, where the participant helps to record ground cover and the number and types of animal species present on the ocean floor.

Scientific discovery games

Scientific discovery games are the third of the three types of online citizen science discussed in this entry. These are online games that are based on an authentic scientific problem. Participants contribute through their puzzle-solving abilities and/or spatial awareness skills. Players do not necessarily need any special scientific knowledge or gaming skills before they start to play. This knowledge can be learned through online tutorials, or from other players.

One of the best known examples of scientific discovery games is Foldit, an interactive puzzle game where players attempt to elucidate the three-dimensional structure of protein molecules. Players can play individually, or within a team, and compete against one another within a points system. Protein structures that come closer to their 'natural' configuration (that is one that requires the least amount of energy) are awarded a greater number of points.

Since its launch, a number of significant scientific breakthroughs have been made by Foldit players. For example, two teams of Foldit players were instrumental in 'solving' the three-dimensional structure of an enzyme relevant to HIV infection – a problem that had confounded biochemists for the best part of decade. Players also use online forums to discuss issues related to the game and the science associated with it.

Scientific discovery games can also offer a novel form of collaboration not only between professional scientists, games designers and interested citizens, but between citizen science players. For example, Foldit players share puzzle strategies, scripting code and help to guide new players through the rules of the game. In effect, Foldit isn't just an online scientific discovery game. It is also a community of skilled games players who are willing to collaborate and share their expertise in the furtherance of cutting-edge scientific research.

Foldit provides an example of the potential of online media for formal and informal learning. The most successful Foldit players have developed expertise and gained skills and competencies in particular areas, forming communities of practice in relation to particular areas of the game. They have gained the requisite knowledge and skills to participate in this scientific endeavour through different routes, in all likelihood combining their experiences of formal and informal science learning to the point where they can share this learning and collaborate with others. If the pioneers of networked infrastructure and the early developers of digital hardware, tools and technologies are reading this entry, they can be proud of what others can achieve individually and collectively through the power of online media.

Cross-references

Citizen Science, Learning Science in Informal Contexts, Lifelong Learning, Public Engagement in Science

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