EXPLICATING THE SHAPING OF EDUCATIONAL TECHNOLOGY: SOCIAL CONSTRUTION OF TECHNOLOGY IN THE FIELD OF ICT AND EDUCATION

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Abstract

Within the Science and Technology Studies, Social Construction of Technology (SCOT, Pinch & Bijker, 1987) is an important approach towards the examination and explanation of sociotechnical systems. Based on the methodology of SCOT, this paper explores the social shaping of educational technology for two cases: firstly, for the debate on the project "One Laptop Per Child"; secondly for the discussion on "Learning Objects and Open Educational Resources." This is to prove the appropriateness of SCOT for an analysis of strategic and political issues concerning educational technology.

Introduction

In scientific, in practical and in political discourses on ICT and education, it is widely assumed that education as a system is adopting ICT for certain reasons. According to Aviram and Talmi (2005), reasons for and related mechanisms of adoption can be interpreted as either technocratic or reformist. In a technocratic view, technology is considered as a mere tool for learning and cannot be ethically judged. Since ICT is changing the world, the introduction of ICT in education is inevitable. In a reformist view, ICT is a driving force for change in the education system for the better and thus to be judged well. But, both paradigms take technology as given. Only a third paradigm introduced by Aviram and Talmi (2005) is defined by the notion of interdependence between culture and technology. This holistic view considers the merger of ICT and education not only to be a matter of adoption, but also to be a matter of shaping and forming technology. Technological development is neither pre-determined nor detached from social development. Little is known about shaping and forming of ICT by forces stemming from the educational system or interests and policies related to education.

Amongst the various paradigms within the Science and Technology Studies (STS), the theoretical framework of Social Construction of Technology (SCOT) (Pinch & Bijker, 1987) offers a social constructivist approach towards the development and adoption of technical artefacts. As a theory and a methodology, SCOT can be characterised by the following facets, which distinguish it from preceding

approaches like technology assessment (Van Eijndhoven, 1997) and related concepts like Actor-network theory (Belliger & Krieger, 2006).

Firstly, through defining relevant social groups that influence the shaping of technology as a core concept (Pinch & Bijker, 1987, p. 30), SCOT addresses a middle level of social connectivity. Neither individual manners of both, acceptance and use concerning technology, are under consideration, nor are wide-ranging developments of global and historical scope discussed.

Secondly, the notion of interpretative flexibility offers a precise and twofold way to understand the social constructiveness of technical artefacts. People attribute not only different meanings to technical devices, thus acting and reacting differently on technical improvements. People also define different problems to be solved by technology. While some discussions on educational technology may consider what technology should be used to solve problems, other debates may disagree whether a certain issue is a problem at all to be solved by technology (Pinch & Bijker, 1987, p. 40).

Thirdly, SCOT has a simple yet convincing model of social dynamics within the shaping of technology. As relevant social groups negotiate about meaning and problem definitions regarding certain technologies, they establish directions of technological development. These negotiations are thought of as a debate on technology, led by relevant social groups in an either open or hidden discourse, reducing interpretative flexibility and aimed at a consensus. A consensus, understood as a closure of this debate, may be agreed upon in various ways. Specific technical solutions may prevail, as well as meanings attributed to technology may be altered, as well as problems to be solved by technology may be redefined. Closures lead to phases of stabilisation in technical development. Then, different relevant social groups share a degree of agreement with formation and use of a technological solution (Pinch & Bijker, 1987, p. 44).

In the following discussion we're going to give reasons for the appropriateness of the analytical level and the concepts that are introduced by SCOT, applying them to two examples of educational technology — the project 'One Laptop Per Child' (OLPC) and the discussion on 'Learning Objects and Open Educational Resources' (OER). Another argument supporting the appropriateness of SCOT for an analysis of strategic and political issues concerning educational technology is presented as a conclusion: Despite being first of all analytic, SCOT offers the possibility to achieve a constructive approach by the idea of inviting relevant social groups for an open discourse.

Shaping of Educational Technology: Two Examples

In the midst of countless rationales, trends, policies and lines in research in the field of ICT and education two projects can be considered as distinctively promising, aiming at better access to education for all: The project One Laptop Per Child and the idea of Open Educational Resources. Both tend to extend the notion of educational expansion on a global level, and both rely heavily on the use of technology as a driving force.

OLPC — a Universal Tool for Self-Education

The project One Laptop per Child (OLPC) is widely known since Nicholas Negroponte and Kofi Annan presented a first prototype of a laptop to be produced at the cost of one hundred U.S. dollars or less at the World Summit on the Information Society in 2005 in Tunis, Tunisia. In the following, some background information is given before recent developments are discussed in terms of SCOT.

Background: A quote from the bug tracking system used by the developers of operating system and applications for the XO-1, also known as the $100 Laptop, brings the mission of the project OLPC to the point:

> Ticket #1 (new defect) There isn't a laptop in the hands of every child. . .Not every child in the world has a laptop. This is a bug. We're fixing it. (Krstić, 2006)

Even if this statement signifies the sense of humour amongst software developers, it is deliberately set as the first entry of the bug tracking system (accessible through the Web) and represents an interpretation of educational expansion solely as a technical issue to be solved like a programming mistake. An inexpensive, connected and robust laptop personally owned by every child provides the ability to learn and progress, especially for children in developing countries.

In order to achieve this goal, the project OLPC, which was founded as a non-profit organisation by faculty members of the MIT Media Lab and is chaired by Nicholas Negroponte, relies on five core principles: 1. Child Ownership, 2. Low Ages, 3. Saturation, 4. Connection, 5. Free and Open Source (OLPC Wiki, 2008). Hence, the laptop makes its impact directly: It is owned by children for free use, not by schools for educational use. Small children are supposed to acquire knowledge and skills easily while playing in their local community which is digitally equipped and connected to the world, enabling them to access free and open software, content, resources and tools. Instead of traditional methods for improving an educational system like building schools, spreading textbooks, reforming the curriculum or educating teachers, self-determination of the children themselves is at the midst of this educational reform, leveraged by a technical device. As the following analysis will show, interests deriving from various relevant social groups influence this approach to self-determination.

SCOT applied to One-Laptop-Per-Child: An analysis using the methodology of SCOT starts by identifying *relevant social groups*. Three of them are quite obvious: the project OLPC itself as a non-profit organisation, the government or education authorities in the targeted regions and, last but not least, various companies that not only sponsor the project but also strive for profit while providing soft- and hardware.

Other related groups are harder to identify: Educators and teachers as single persons or organised in unions and lobby groups can be named as well as non-governmental organisations involved in development aid. But also scholars and researchers are participating in the OLPC project. The University of Potsdam for instance proudly informs that German students of computer science adapt gaming software for the OLPC laptop (Hasso Plattner Institut (HPI), 2007). Furthermore, the project OLPC counts as a test bed for the large-scale implementation of a mobile mesh network, i.e. a mobile ad-hoc network of digital devices (Carrano et al., 2007), and is thus promising new insights on applications for mobile computing.

Relevant social groups share common interests in relation to a specific technical project. These interests can be described as a connection between a defined problem and a proposed technical solution. As the example of the attempt to deploy a mobile mesh network at large scale illustrates, the definition of problems to be solved by educational technology may diverge from primary pedagogical aims. Researchers and scientists from technical disciplines participate in educational projects in order to develop technical solutions. However, technical solutions tend to solve technical problems. Undoubtedly, mobile mesh networks implicate a benefit for the pedagogical aims of the project OLPC. They contribute to the core principles of OLPC (see above in section Background), especially to ‘Saturation’ by enabling a digital equipped local community, as well as to ‘Connection’ and to ‘Free And Open Source’ by connectiveness (OLPC Wiki, 2008).

But working on hard to solve technical problems harbours danger of loosing track of the original pedagogical aims. In addition, technical solutions, where mobile mesh network technology is just one of numerous technologies supported by the use in education, are generally not determined in their use. This versatility, being a defining attribute of what we call ‘technology’, often leads to an overload in educational technology projects with technical challenges. Then, an educational project serves as a field of development for technology, rather creating than solving needs and problems to be solved by a specific technology.

Between the initially named three relevant social groups, i.e. the non-profit organisation OLPC, the administration in targeted regions and commercial

producers of hard- and software, the dynamics within the unfolding of the project OLPC draws attention to primarily economic issues. These negotiations can be analysed in terms of *interpretative flexibility*.

A distinctive attribution towards to educational technology in the project OLPC is to interpret a technical device, i.e. the laptop, as a tool in hands and ownership of the single learner. This attribution is stated in the core principle 'Child Ownership' (OLPC Wiki, 2008) and stands in contrast of former projects of educational technology which were centralising the access to technology, i.e., building on educational television or computer rooms in schools, thus rather restraining access than enabling it (Rink, 2007, p.144). When India declined the participation in the project, a need for more classrooms and more teachers rather than for 'fancy tools' was asserted by India's Education Secretary Sudeep Banerjee (cited in Butler, 2007, p. 6). The same way international aid agencies claimed the need for very basic requirements like water, food and shelter instead of a laptop provided to children in the least developed regions of the world. But the project OLPC does not define these regions as targeted regions, and wants to concentrate mainly on the G20 developing nations (Rink, 2007, p.145).

Furthermore, the public debate about the involvement of big companies from the computing industry can be analysed in terms of interpretative flexibility. The effort made by the project OLPC has drawn attention to emerging markets for ICT in developing countries. A cheap, but ubiquitous digital device in the hands of school children is not primarily a way for self-education, but becomes a way to develop these markets. Use of ICT in education is of importance, since systems used here are likely to be used later in everyday life and for work. This led to — apparently hasty — presentations of alternative products for educational use in the hands of school children in developing countries. While Craig R. Barrett, in his former position as CEO of the Intel Corporation, first dismissed the OLPC-Laptop '$100 gadget', Intel later presented the 'Classmate', a more powerful laptop at the cost of 400 U.S. dollars. The Microsoft Corporation offered different technical solutions, from mobile phones with PC-capabilities (FonePlus™), then a functionally limited version of MS-Windows™ at low cost on refurbished computers from industrialised nations to finally an 'IQ PC' for India at the cost of 500 U.S. dollars (Butler, 2007; Surowiecki, 2006).

In the sense of SCOT, this variety reflects early stages of a development process, where different technical solutions are imagined and controversially disputed. When the debate is settling, a *closure* of the debate can be stated. The temporary involvement of Intel within the project OLPC was a closure in that sense. When Intel was joining the project in summer of 2007, a consensus was reached in interpreting the Classmate-laptop and the OLPC-laptop as both adequate solutions for different problems: Since the laptop from Intel needs power supply, it is more

suitable for urban areas, while the laptop from OLPC, which can be powered using a hand driven dynamo, is more suitable for rural regions. As this closure was rather rhetoric than substantial, the controversy was continued, leading to the leave of Intel from OLPC in the first months of 2008.

Other closures in the debate on OLPC are apparently more stable. On the one hand, phases of *stabilisation* in technical development imply opportunities for refinement of technical solutions. The work on the graphical user interface for the OLPC laptop XO-1 called 'Sugar' with remarkable new design features can be considered as the enhancement aimed at the requirements of creating a highly sociable computer tool. On the other hand, stabilisation offers opportunities for refining interpretations and assigning comprehensive attributes to technical solutions. For the moment, the project OLPC is regarded as a best practice example for a public-private partnership (Surowiecki, 2006).

OER — Universal Access to Educational Resources

The MIT OpenCourseWare Inititative announcement in 2001 to make MIT course materials available on the World Wide Web without any access restrictions is usually taken as the point of origin for the idea of Open Educational Resources (OER). Meanwhile, institutions and networks form a movement aimed at universal access to educational resources using web technology. This movement started from local or national initiatives and has grown onto a transnational or a global level, e.g. by the formation of the OpenCourseWare Consortium (OCWC), by the founding of GLOBE (Global Learning Objects Brokered Exchange) for the collaboration of the major North-American, European, Australian and Japanese initiatives or by the launch of OER Commons, a network supported by the William and Flora Hewlett Foundation. After noting some interesting thoughts on the interdependence between OER and the discussion on Learning Objects in the following, some issues in this movement are reinterpreted in terms of SCOT.

Background: A very strong and often quoted argument for the impact of educational resources available through the Web was made a few months after MIT's announcement by Stephen Downes:

> The first assumption is that there are thousands of colleges and universities, each of which teaches, for example, a course in introductory trigonometry. Each such trigonometry course in each of these institutions describes, for example, the sine wave function. . . . Now suppose that each of these institutions decided to put its 'Introductory Trigonometry' course online. . . .The result will be thousands of similar descriptions of sine wave functions available online. Now for the premise: the world does not need thousands of similar descriptions of sine wave functions available online. Rather,

> what the world needs is one, or maybe a dozen at most, descriptions of sine wave functions available online. (Downes, 2001, p. 1)

There are two presuppositions in this argument: Firstly, it is assumed that the description of the sine wave function is more or less the same no matter what institution is teaching it. Secondly, as Downes continues, courses like an introduction in trigonometry can be broken down in pieces, which can be used as resources for learning in other courses assembled from those pieces (or, more generally spoken, for learning in learning experiences that also could be self guided). This is the essential idea of Learning Objects, hence forming the technical basis of Open Educational Resources as an approach towards educational expansion.

The notion of Learning Objects (LOs) implies quite a number of technical problems, which were prominent in research and development of technology-enhanced learning for the last years. Because LOs (or Open Educational Resources respectively) must be searched and found, issues of information retrieval were addressed by research on educational metadata and ontologies, leading to research on semantic web and social software. Operating Learning Object Repositories led to questions of business models, quality assurance and incentives for contributors. Requirements of interoperation between LOs and runtime environments (i.e. learning management systems) as well as between different Learning Objects Repositories stimulated the standardisation process in education related ICT, where Learning Objects Metadata (IEEE-LOM) and the Sharable Content Object Reference Model (SCORM) are the most common amongst other specifications devised by institutions like the IMS Global Learning Consortium or the CEN (Comité Européen de Normalisation, the European Committee for Standardisation).

In view of the efforts towards interoperability and standardisation related to Learning Objects, the movement of Open Educational Resources is not only an issue of educational change, but also a large technical project. The OLCOS roadmap (Geser, 2007), issued by the European project Open eLearning Content Observatory Services, comprises a both current and comprehensive account of the discussion in progress and is therefore an appropriate reference for the following argumentation.

SCOT applied to Open Educational Resources: In the analysis of Open Educational Resources as a technical project in terms of SCOT, the *relevant social groups* can be divided into three different levels of organisations.

At top level, governmental bodies share a problem definition with economic stakeholders: Skilled and thus employable citizens create wealth or profit respectively, where universal access to educational resources provides the opportunity for life-long and flexible learning (see Geser, 2007, p. 20).

On a corporate level, educational institutions like universities and commercial publishers of educational content are equally challenged by the universal access to knowledge via the Web, whereof the idea of open access to educational resources is just one facet. On the one hand, the business models based on restricted access have to be abandoned, no matter whether hitherto access has been granted as an admission for study towards an academic degree or on the basis of fees and costs. On the other hand, where academic institutions and especially projects producing digital educational resources are founded by public, unrestricted access for the public is a justified claim. Both educational institutions and publishers have to generate new business models and therefore share a view on OERs rather as a problem than a solution, even if this is not openly acknowledged by the former (Geser, 2007, p. 64).

On the bottom level, users, i.e. scholars, teachers and students, see universal access to educational resources as a solution for individual learning needs. Both expect benefits of high quality — saved efforts in making use of or producing educational resources as well as revenues for publishing resources, may the latter be monetary or an increase in reputation (Geser, 2007, p. 21).

Again, also researchers and scientists from technical disciplines participating in projects on OER can be analysed as a relevant social group and would be positioned rather on a medium than on a top or bottom level. As shown above in the brief discussion on the interdependence between OER and Learning Objects, granting access is a major technical challenge, because strict rational issues are interwoven with semantic questions in the design of systems for information retrieval (Geser, 2007, p. 82).

With the notion of access at the midst of problem definitions and prospective solutions conceptualised by all named relevant social groups, the level of agreement within the social construction of OER seems to be rather high. Nevertheless, its impact on educational practise is still modest. As main inhibitors a lack of business models is stated, especially for sustainability beyond funding within research projects and for the coexistence of open and commercial content, as well as missing models and routines of training, motivating and rewarding scholars and teachers for their contribution to open accessible educational content (Geser, 2007, pp. 64–70).

But beyond stating the lack of models and routines in OER, this gap is likely to be of systematic origin. This origin is possibly to be found in an *interpretative flexibility* in terms of SCOT; hence in different notions concerning access to educational resources attributed by different relevant social groups. In the view of governmental bodies that are funding projects in OER, access means using intellectual property at large scale for the benefit of the national economy. Alternatively, employers regard intellectual property as a corporate resource and strive for access to rather small pieces of knowledge, enabling learning just in time for a flexible workforce. While the first are interested in broad access for all, the second tend to restrict access to an efficient and targeted use.

At users' level, the notion of access corresponds to a model of self-determination. Both learners and educators expect choice as a connotation to access, not only choice of high-quality content for acquiring specific skills or knowledge, but also choice of what to learn, expanding learning opportunities beyond the syllabus set up by educational institutions. On the one hand, this idea of free choice implies a notion of a liberal market economy for educational resources, where the best content will succeed. On the other hand, free choice implies a notion of self-determination in the sense of self-regulated learning. Both implications transfer the idea of free and open source software to education (Geser, 2007, p. 59).

These different interpretations of access to educational resources can be summed up in an antagonism of open and targeted access, the latter implying restrictions rather than universal availability. This antagonism is negotiated in the *debate* on technical solutions and use of OER, e.g. in considerations and recommendations, which kind of educational resources should be made available to the public by academic institutions. While course materials are available, educational services like mentoring and assessment leading to a certificate are subject to permission, fees or both.

Another issue in a debate rises from the postulation of self-determined choice of educational resources as a choice of what to learn, in a sense of self-regulated learning leading to more informal instead of formal learning processes. This user-driven approach towards OER conflicts with the regulating role of educational institutions in arranging skills, competencies and knowledge by means of curricula and syllabi. Therefore, educational institutions have to redefine their position. In terms of SCOT, this means a possible *closure*: Educational institutions like universities as well as commercial publishers of educational content move away from trustees of knowledge to intermediate agencies in the free flow of knowledge. Educational institutions offer guidance in a world of universal access to educational resources, while publishers act as brokers, both abandoning their mission as producers of educational resources.

Presumably, this closure will lead to *stabilisation* where not only business models are devised, but also technical systems are designed and developed addressing the needs of guidance and brokerage. Access is seen as an issue of information retrieval, collaborative quality assurance and social navigation, while issues of intellectual property and access restriction are to be addressed by digital rights management.

But within this stabilised view, Downes' above named two presuppositions concerning learning objects has to be complemented by a third one: The access to an educational resource is meant to be learning itself. But in spite of reducing learning to receiving, digesting and reproducing knowledge, it is recognised by many contributors to the discussion on OER, that learners develop skills, competencies and knowledge by using educational resources as a tool. This pedagogically common emphasis on practice and process instead of product and content is, for example, reflected in the notion of 'canned products' with 'open practices' (Geser, 2007, p. 44).

Conclusion

Using two examples of educational technology, the project One Laptop per Child (OLPC) and the discussion on Learning Objects and Open Educational Resources (OER), the methodology of Social Construction of Technology (SCOT) was applied to technological developments in the field of ICT and education. Being far from exhaustive, both analyses demonstrated that SCOT is appropriate for the description and the understanding of groups, interpretations, concerns and dynamics in the process of design and development of educational technology.

There are, of course, approaches towards this field aiming to reach beyond the scope of SCOT, especially from the viewpoint of Critical Theory. Authors like Andrew Feenberg and Maria Bakardjieva abandon this methodology as neglecting underlying relations and structures beyond the sovereignty of the rational subject (Selwyn, 2007, p. 84). This is a strong argument for regarding the scope of SCOT as limited. This limitation is, of course, demanding for a future profound discussion on social construction of technology in the field of ICT and education.

Nevertheless, a final point for SCOT as a methodology has to be made. SCOT is an analytic approach, and is thus deconstructing debates by the description of involved groups, their interpretation of both, problems and technology as well as observable dynamics. However, in a pragmatic approach for both, pedagogical and political objectives, SCOT offers a link to social action, when we leave the analytic stance and reconsider the given debate as an open and reflexive discourse that can be enhanced towards the participation of people concerned with educational technology. The programme of constructive technology assessment

(CTA, Genus, 2006) advances approaches of technology assessment towards a specifically participatory notion and aims for the inclusion of various social groups for assessment of and decisions on emerging and developing technologies.

Participatory and dialogue-based processes in technology assessment prospered in Denmark and Netherlands, involving the public for example in the development of information technology and biotechnology by means of consensus conferences and dialogue workshops. This kind of participation only informs the parliamentary processes and hence does not directly lead to relevant decisions. However, it organises an iterative discourse between relevant social groups and developers of technology (Genus, 2006, p. 7). From this viewpoint, participatory processes deserve more effort in the field of ICT and education, beyond just analysing the shaping of educational technology.

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