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Book Review

The Impact of Technology Education: International Insights

De Vries, M. J., Fletcher, S., Kruse, S., Labudde, P., Lang, M., Mammes, I., Max, C., Münk, D., Nicholl, B., Strobel, J., & Winterbottom, M. (Eds.) (2020). The Impact of Technology Education: International Insights. Münster & New York: Waxmann.

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Introduction

The edited book *The Impact of Technology Education: International Insights* was published by Waxmann on behalf of the Center of Excellence for Technology Education (CETE), which operates out of the University of Duisburg-Essen, Germany. The book includes nine chapters covering a diversity of topics and methods, ranging from quantitative studies of technological self-efficacy, technological literacy, and digital competencies to qualitative studies of the significance of gaming for decision-making capabilities, the importance of tinkering and making for technology education, and national evaluations of technology education. *The Impact of Technology Education* is thus a multi-faceted book which is also truly international with altogether eleven editors. It includes researchers and contributions from Germany, Switzerland, Luxembourg, the Netherlands, the UK, and the USA, but the majority of chapters deal with research made in and about the German-speaking countries.

Overview of chapters and themes

The book begins with a short preface that introduces the main, overarching theme of the book – the impact of technology education – as well as including a brief overview of the chapters of the book.

The first chapter is entitled “Primary-school pupils’ self-efficacy and its influence on solving technological problem-based design tasks” and was written by Victoria Adenstedt and Annika Gooβ. They set out to present two works in progress and the first results of these studies. The authors re-introduce the concept of *technological self-efficacy* from McDonald and Siegall (1992) to denote pupils’ self-efficacy concerning technological tasks in particular. There are two different aims of the chapter, one for each of the two ongoing studies: 1. to investigate the technological self-efficacy beliefs of primary-school pupils; and 2. to determine whether differences in the solving of a technological problem-based design task between pupils exist, and whether one can detect an influence of self-efficacy and previously gained experiences. Gender perspectives are also important features of the two studies.

Although the second study is really only partially reported and thus inconclusive, the results indicate that nine-year-olds show above-average technological self-efficacy expectations, especially among boys. At the same time, in the problem-solving task a slight majority of the pupils rely on assistance from the teacher rather than trust their own capabilities, which might be interpreted as indicating a less prominent technological self-efficacy.

The second chapter of the book was written by Stefan Fletcher and is entitled "What distinguishes a technology literate pupil? Conception and development of a test instrument". Technological literacy and related concepts like technological capability and technological competence feature a great deal in connection with the development of curricula and standards in design and technology education (e.g. Doyle, Seery, & Gumaelius, 2019). However, little is known about the actual technological literacy of pupils, probably because it is still a vague and amorphous concept. Fletcher's chapter thus reports on the construction and validation of a test instrument for measuring the technological literacy of pupils. It is by no means a small venture and thus this research was initiated by the Center of Excellence for Technology Education, and also includes the University of Delft, the University of Luxembourg, the University of Education Schwäbisch Gmünd, and the University of Applied Sciences and Arts Northwestern Switzerland.

The chapter involves the definition of technology and technological literacy, with the following characterization of technological literacy: "The ability and willingness, on the basis of technology-oriented concept, everyday related and evaluation knowledge, to successfully execute typical technical forms of actions in different application contexts and to be able to estimate the consequences for themselves and for society" (p. 35). It should be noted that this definition was not based on any technological or philosophical literature. However, the succeeding design of the test instrument and the included types of technology used for testing technological literacy of pupils, were thoroughly informed by the analytical philosopher of technology Günter Ropohl (e.g. Ropohl, 1979). The resulting test items and task format are described, as are the results of the performed trials of the content validity of the questionnaire.

Chapter three is called "Affinity for technology of girls and boys of lower secondary school level", and was written by Karin Güdel, Anni Heitzmann and Andreas Müller. It investigates the effects of an intervention on the affective and cognitive variables of pupils' "Affinity for Technology" (AFT), conceptions of technology and technical/technological competencies. The intervention is of the classical kind with experimental group and control group. The AFT of the pupils in the experimental group is investigated through the lens of general acceptance of technology (attitude), individual interest, self-efficacy in solving technical tasks (a kind of technological self-efficacy, see above), and career aspirations, in several different contexts.

The conclusions of this chapter are manifold. The general attitude toward technology of most grade 7 and grade 8 pupils in the study is more positive than when technology is related to specific contexts. The authors conclude: "Hence, interest in technology drops with an increasing specificity of the context" (p. 54). Regarding gender, girls' perceived self-efficacy is lower than boys' in most technical activities, except for when planning and designing where they exhibit the same level as boys. Regarding the effects of the intervention, 75% of the pupils liked the technology class regardless of gender. The AFT was also lower in grade 9 than in grade 7, regardless of gender and whether one was part of the experimental group or the control group.

Christian K. Karl and Heide Lukosch wrote the fourth chapter, entitled “Increasing decision making competencies by applying simulation and gaming in technology and engineering education”. It deals with two game interventions and how they affect engineering students’ decision-making capabilities, in a German higher education setting. The intervention involves both a regular board game designed to include decision-making alternatives (Decision Areas, DA) for a construction contractor in procurement activities, and a virtual game involving technology-related problem-solving and decision making.

The authors conclude that students can learn about decision making in a lucid setting through game interventions, not only by playing but also by designing such games. They offer some implications for how to design successful games for technology and engineering education, based on, among other things, decision-making theory. One final remark is that there is evidence that online, database-driven games may have promising affordances and could play an even more vital role in teaching and learning in blended scenarios, that is, where real-life and virtual learning contexts are mixed.

The fifth chapter was written by Stefan Kruse and Alexander Franz Koch and is entitled “Competences in a digitalised world in the context of general and vocational technical education and training”. The chapter is based on a larger, previous Swiss study but here applied to a German context. Thus, in the current chapter there is a secondary analysis of a quantitative Delphi study performed with German experts in relation to the German VDI technical competence grid (VDI is the Association of German Engineers). The participating experts were professional engineers, VET (Vocational Education and Training) practitioners in engineering, and school teachers in technology, and they rated the educational relevance for the transition from school to VET or university, and the overall future potential, of three central technological domains: internet of things (“smart” networked artefacts), cyber-physical systems (e.g. navigation systems), and socio-technical systems (in this context, human – machine/computer systems). The central problematic was thus how well standards meet transitional requirements.

The results of the study show that there was generally a high degree of agreement among the experts, but the VET practitioners rated items slightly lower than the other groups. Furthermore, the domain internet of things was considered the most relevant content area in terms of transition to vocational training, but not to university. The internet of things was thus seen as more practically oriented than, for instance, socio-technical systems, which were regarded as more geared toward higher education. However, the experts did not agree regarding the relevance of socio-technical systems for VET.

Chapter six, “Technology education in pre-school and primary school” by Ingelore Mammes, deals with the inclusion of technology education in early education, that is, pre-school education and primary education, in Germany. The chapter includes a qualitative analysis of technology in pre-school and primary education curricula, which generally do not feature a subject called “technology”, in 14 German federal states. The findings of the study presented in this chapter show that almost all federal states include technological content in their curricula for social studies and science, although it is not labeled as technology but is submerged under other headings. More concrete content – such as everyday and playground equipment, model making, stability and bridges, the proper handling of tools, machinery and equipment, and

materials – are featured in most states' curricula. Mammes concludes that although the situation regarding technology in early education has greatly improved in recent years, it still needs to be further developed.

Chapter seven, entitled "Tinkering *with* technology education" and written by Elizabeth McGregor Jacobides and Mark Winterbottom, provides an argument for the inclusion of tinkering and making in technology and engineering education. The theoretical basis can, according to the authors, be found in Jean Piaget's constructivism and Seymour Papert's constructionism, but they also bring in several other frameworks and theoretical insights. Although the chapter really is about tinkering, there is also a great deal of reference to making as its mirror image, because making is what is going on in technology and engineering education a great deal. However, the authors point to the fact that "Making emphasises *product*, Tinkering emphasises *process*" (p. 119).

In this regard, the chapter makes the point that tinkering could really infuse engineering and technology education as a space in between self-directed and supervised learning. In particular the chapter makes the argument that the engineering design process shares many similarities with tinkering, and proposes a model that includes both engineering and tinkering in seven related areas: Pupils are engaged in purposeful, practical problem-solving; pupils take ownership of the design and make process; pupils embrace and learn from failure; pupils' curiosity and creativity are responded to; pupils demonstrate mastery from other curriculum areas (most notably STEM, according to the literature they build the model upon); pupils draw on a range of thinking skills and personal capabilities; and pupils' learning experiences are guided by a whole-school approach (p. 134).

The eighth chapter in this volume, "Current state and suggestions for the K-12 STEM school industry partnership in the United States" by Johannes Strobel and Yan Sun, takes as its starting point efforts in the USA to improve STEM education in schools by forming partnerships with various societal actors. More specifically, the authors designed a taxonomy of K-12 STEM school-industry partnerships, after examining 72 such cases through a literature review. The taxonomy consists of focus discipline (integrated STEM, or individual STEM disciplines), target audience/school level, role of school, role of industry, and role of third partner which could be, for example, any level of government, teachers' associations, or higher education institutions.

Based on the taxonomy, a model is also proposed for building effective K-12 STEM school-industry partnerships. The model focuses on optimizing such school-industry relationships so that it is possible to utilize the strengths of both parties, with help from third parties such as colleges or universities. The authors also issue some recommendations for successful partnerships: 1. Commitment from school partners is necessary to make the programs work; 2. There is a difference between a donation and a partnership, which must be understood to be able to make a difference in the partnership programs; 3. The programs should focus on research-based STEM education curricula with proven track records; 4. More programs should focus on underserved and underrepresented talent pools; and 5. Efforts should be made to create programs to capture pupils' interest in STEM at an early age (p. 157).

Chapter nine is entitled "National evaluations of technology education: what do they tell us about the impact" and was written by Marc J. de Vries. The author takes up the introduction of

technology education as a separate subject in many countries in the 1980s and 1990s, and subsequent efforts to follow up this introduction by way of national evaluations. The chapter deals with two national examples, one national evaluation in the Netherlands in the late 1990s, and one evaluation in England in 2007-2010. The aim of the chapter is to describe and discuss the nature and outcomes of these two national evaluations, and to investigate to what extent it is possible to establish whether the promises made when introducing technology education were actually met.

The author shows that there were many similarities between the two national evaluations, for instance, the ways they were performed through school inspections. Furthermore, the state of the subjects Technology and Design and Technology respectively was quite similar in that in weak schools' technology teachers were isolated and only implemented parts of the curriculum. As regards differences, in the Netherlands the focus was very much on making skills, but without the design element, whereas in England the focus was on design that also included the making of a product. Pupils were also more positive about the subject in England than in the Netherlands. It must be emphasized here that these are two historical evaluations that do not necessarily reflect the situation today, although a lot still seems to be the same as de Vries points out.

Conclusion – weaknesses and strengths

Regarding weaknesses, the book's theme of the "impact" of technology education is vague and could mean a number of things. In the preface, it is defined as "the impact it has on the personality development in technology" (p. 8), and this definition might include some of the first chapters. The final chapter by de Vries also relates to the impact of technology education, but on a more general level in relation to national educational evaluations. This was really what I first expected when I read the title. A more comprehensive theme could have made the title more inclusive of the variety of studies in the volume. Another weakness is that the book includes several ongoing studies which have inconclusive findings. Finally, I miss a more thorough critical perspective on technology and technology education, for instance, in relation to the issue of impact. It could be anything from the importance of critiquing when designing in order to make products more sustainable (e.g. Williams & Stables, 2017) to including in technology teaching discussions of the implications of technology development for a future society, for example, the impact of artificial intelligence and human-machine systems on job opportunities (e.g. Hallström, 2019).

However, in terms of the strengths of the book, some such critical perspectives do feature in certain chapters. Chapter two deals with the issue of evaluation of technology as a feature of technological literacy, and chapter five discusses the possible future effects of socio-technical systems/human-machine systems on the job market. De Vries, finally, connects the theme of impact to a critical perspective when he claims that "the whole idea of having technology in schools is in the factual social impact ON technology and the desired social impact OF technology" p. (172).

Another strength that applies to the whole book is that *The Impact of Technology Education* offers a comprehensive compilation of technology education studies from primarily German-speaking European countries, which is very much needed. Researchers from, for example, Germany and Switzerland do not publish in international English-language journals such as the

International Journal of Technology and Design Education or *Design and Technology Education: An International Journal* to the same extent as researchers from the USA, the UK, Australia, New Zealand, Western and Northern Europe (e.g. Xu, Williams, Gu, & Zhang, 2020). It is evident from this book that a great deal of highly relevant and novel technology education research is produced in German-speaking countries and therefore never reaches an international audience. One can only hope, for example, that the actual, future findings of the promising international investigation of pupils' technological literacy in Chapter two will be published in an English-language journal or book (chapter). The fact that *The Impact of Technology Education* includes such international studies that also connect German-speaking researchers with the American, British, and Dutch research community only adds to the value of the book and its contributions.

In particular, I want to commend the studies in the beginning of the book dealing with pupils' attitudes to technology (education), and attempts made in these studies to measure pupils' technological literacy and technological self-efficacy, in relation to central issues such as gender. The chapters on digital competencies in vocational education, tinkering/making and early childhood education are also highly relevant and much needed to develop the field of technology education as well as teaching in schools.

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