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A Delphi study on the future of technology education

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Abstract

In 2020 an article about American experts' opinions on the future of technology education was published. Several concerns were expressed by the experts in the Delphi study that had been conducted, such as a shortage of teachers and funding. From the start of the study in the USA, the idea was to conduct similar studies in other countries. It is interesting to see to what extent the outcomes are USA-specific or more broadly valid. To find that out a similar study was done in Flanders (the Dutch-speaking part of Belgium) and the Netherlands. In our Delphi study, consent was found among the experts in three rounds. It became clear that there are similarities between the USA outcomes but also differences. Most of those differences can be explained by taking into account the local developments in the different countries.

Keywords

Delphi study; impact factors; expectations for technology education

Introduction

The position of technology education in the school curriculum still today is not always to be taken for granted. Although good practices are available in various countries, there is still confusion among school boards, parents, and policy makers about the purpose, focus, and content of technology education. The historical craft tradition, out of which technology education emerged in most countries, still lingers around in discussion about how to teach technology in school. Adding the term “engineering” to “technology education”, as was done in the USA (in the name of the main teacher association this led to the change from “International Technology Education Association” into “International Technology and Engineering Education Association”) was an effort to show that technology education had left its craft past behind. In other countries there is hesitation to add that term to the name of subject and association because of the vocational “flavour” that sometimes comes along with the term “engineering”. The developments towards STEM (Science, Technology, Engineering and Mathematics) education have added to the confusion, as this acronym, and the educational developments associated with it, raise the question of how technology is related to science and math and what the term engineering means in the context of a situation in which engineering is not a school subject like science and math.

All together the future of technology education is not easily predictable. Yet it can be worthwhile to ask selected experts what their ideas about this are. This was done in a Delphi study conducted in the USA and reported by Moye et al. (2020). Their study was not a standard Delphi study in which a selected group of about 25–30 experts respond to outcomes of the previous round so that in (usually) three rounds a consensus can be established. Instead, 268 participants were involved in the third and final round of the USA study. The similarity with the traditional Delphi set-up outcomes of one round were fed back into the next so that respondents could change their opinions based on the averages found of the previous round (which eventually leads to consensus). The main outcomes of the USA study were that respondent expressed concerns about the lack of technology teachers and the lack of funding for programmes. The identity and perceived relevance of technology education also was a reason for concern, as was the quality of teacher preparation. A positive outcome was the increased attention of student inclusion and equity. In the discussion of the outcomes, the authors show how the outcomes can be understood in terms of actual developments in the country.

This raises the question as to what extent the outcomes of the USA study are specific for this country and to what extent they are more broadly valid. From the very start of the USA study, the idea was to conduct similar studies in other countries. In Finland, a study was done by Niiranen (2022) and others. In the Dutch-speaking part of Belgium (Flanders) and in the Netherlands, the historical development of technology education is different. That makes it worthwhile to do another similar study there.

In order to get a correct perspective of experts’ views on the current and future factors and issues, we first give a broad overview of technology education’s history in the context of our study. Subsequently, we provide an answer to the question of what is impacting technology education now and in the near future, and what the emerging topics are.

Historical context of the current situation

Flanders

Demaegt (2017) describes that in 1963 there was a technical/technological subject in Flanders. At that time, it was still a very practical subject, focused on manual labour, with the aim of estimating the technical capacities of a student to be able to orientate them. From that moment on, technological education will be part of the curriculum of all students in the first two years of secondary education.

In 1970 there was a change in which technological education was no longer included in the general curriculum of all students in the second year of secondary education, but in the option package. At the same time, the lesson packages for boys and girls are equal for the technical subjects. Negotiations leading up to this change also considered how science interacts with technology.

In 1971 the “renewed secondary education” started in Flanders. Technology is described as follows:

> It is clear that 12-year-olds cannot participate in and gain insight into the real technological process, i.e., they cannot yet follow the path of the designer, whose task was to transform the raw materials into useful objects to make … What they can do, however, is take the road in the reverse order: they can technologically study, dissect, explain, and understand simple and well-chosen objects (finished products). Initiation into technology thus means that one gains insight for the first time into everything that was necessary and what the builder had to take into account to make even very simple objects (e.g. a pencil).
>
> The aim of this initiation is certainly not to lay a foundation early on for a specific vocational training or to impose technical subjects, but rather to think about technical problems. (Pedagogisch bureau van het NSKO en NVKMO en NVKTO, 1971)

In 2022, the focus is much more on the students' independent discovery and on walking through that technological process themselves. The opposite of what is said in 1971. Nevertheless, the last sentence still stands in 2022.

In the 1970s, it became clear that technological education, despite the earlier aim of the subject, was regarded as a preparation for technical education. However, the technical schools also question the usefulness of the technological education subject. Although this is not the original objective of the subject, the schools argue that two hours a week does not provide a sufficient basis for students who transfer to a technical direction after two years of observation. This shows that the schools clearly do not see the subject as an orientation subject to observe the technical affinity of a student, but really as a stepping stone to a thorough technical education and as partial compensation for the two lost years of technical education compared to the traditional technical education. This was not the original design of the profession at all. In addition to the problem of substantive content, the training of technology teachers also appears to be a major problem.

In the early 1980s there were still some small shifts in the number of hours, but the status quo largely remained until after 2000.

In 2004 the TOS21 working group was started up from the Department of Education and the Department of Science of the Flemish government. The aim of the pilot project is to tackle several major problems that arise in Flemish education in the field of technology. TOS21 stands for Technology at School in the 21st century and must work on a sound development of technical education. The objectives of the project are divided according to the departments. For education, the focus is mainly on the development of concrete attainment targets for primary and secondary education. For primary school, these are further integrated into the subject "world orientation", while in secondary school, on the one hand, they build further on the technological education subject in the first stage, and on the cross-curricular attainment targets, on the other hand, for the higher degrees. The objectives in the field of science can mainly be situated in broadening the interest in science and technology (Moens, 2008).

However, the major objective, apart from the above, remains to make young people enthusiastic about technology. A report by the federation for technology industry (Hauttekeete, 2007) shows that 45 per cent of young people do not want to work in a technology company. Such companies are all too often associated with band work. The sector concludes that technology has too much of an image problem.

From 1 September 2010, technology education has a new curriculum, with a focus on "technical literacy for everyone".

In 2014, the renewal of secondary education is once again on the agenda. Ardies and Boeve-de Pauw (2014) propose a two-track policy with regard to technology in education. The first is a socially motivated perspective for broad technical literacy, based on the idea that every citizen should be able to participate optimally in society. The second, more economically inspired track is the demand from the labour market for sufficient technically skilled workers. They also describe that in the past too much emphasis was placed on "doing" during the lessons, and too little on understanding and interpreting technology. The place of technology within STEM also remains an important point. van Houte et al. (2013) already stated that the integration of certain elements does not necessarily mean a fusion.

In 2015, the Flemish government formulates a STEM framework for Flemish education (Scheys, 2015). This is partly the base for the new educational goals for secondary education, which started in the scholastic year 2019–2020.

In these educational goals we no longer find separate goals for technology. They are now integrated in STEM, although with its own frames of reference. For example, we read in this policy document on the principles of the educational goals (Vlaamse Overheid, n.d.) under 1.1.1:

> Because of the clear individuality of the Mathematical competence, the Scientific competence and the Technological competence, it was decided to develop separate frames of reference for each discipline. By no means do we want to give the impression that there is no strong link between the three disciplines, on the contrary.

In the frame of reference for technology 1.1.3.3 we read:

> Daily life, thinking and acting are increasingly determined by a stream of technological developments. Optimal functioning in a rapidly changing knowledge society presupposes, in addition to the skills to use technological instruments and machines, the development of technical thinking and acting.

Anno 2022 technology will retain its place in the curriculum with two hours a week in the first two years of secondary education. In primary school, technology is no longer in the subject “world Orientation”, but in the less broad subject “science and technology”.

The Netherlands

In the Netherlands, technology education was introduced as a separate school subject in lower secondary education (pupil ages 12–15 years) in 1993. In-service education programmes were set up to re-educate teachers of other subjects to become technology teachers. Later, the government initiated a national programme for primary teachers also but left it to primary schools whether they would implement technology education or not. Only some superficial standards were formulated, and these did not have much impact on what happened in schools. For upper secondary school, it was decided to have technological elements in the exam syllabi for physics, chemistry, and biology. These were updated, and more contextual topics were added (domains of application) and more attention was paid to inquiry and design. Particularly the design assignment that is now part of the exam syllabus contains a clear connection with technology. Today, however, science teachers still struggle with the implementation of this assignment, as they never had any design experience in their teacher education. In practice, the design assignment in science education does not mean much. Several of the contexts in the new exam syllabi are technological in nature, but they merely serve as an appetiser for studying the science that underlies the functioning of technological devices. There is also some attention for the social consequences of these technologies but how the science was used to design the devices is not well covered. In 2000, schools were also given the option to integrate technology education in science education, and many schools did this. In the 2010s a new type of school was developed called Technasium schools and they had a subject “researching and designing” (in Dutch: Onderzoeken en Ontwerpen, abbreviated O&O) that often was implemented not next to but instead of technology education. Around the same time for upper secondary a new (elective) school subject called nature, life and technology (abbreviated NLT) was initiated. This subject can truly be called integrated STEM and several of the modules that are taught have design assignments. The current situation is that the number of schools that still have a separate subject technology education in lower secondary school is much lower than before but stable, and in upper secondary education technology education is part of science education (in the exam syllabi and in the subject NLT). In primary education there is still an increasing number of schools taking up technology education, and teachers are supported by regional so-called science-and-technology hubs. The most recent development is called Curriculum.nu. It entails a complete revision of the curriculum for primary and secondary education. New standards have been formulated for nine “learning areas”, one of which is called “Humans and Nature”. Science and technology education standards can be found here. The idea is that schools can decide how to organise the curriculum, but it is suggested that boundaries between the existing school subjects are made more porous. It is not quite clear what will become of this initiative, as at the moment it is still in political debate.

In primary education there is an increasing number of schools that implement science and technology education as an integral domain. Support is offered by science hubs of which most Dutch universities have. These hubs develop materials and activities for pupils (some of them with a Citizen Science character) and do training sessions with primary teachers. Some institutes for primary teacher education have implemented modules that prepare future primary teachers for teaching science and technology. In some cases, these programmes are developed in cooperation with a science hub.

Methodology

Research questions

In this Low Lands study we used the following research questions:

1. What currently has a positive/negative impact on science and technology education?
2. What trends will most likely impact the technology and engineering education profession in the next three to five years in a positive/negative way?

3.a. What new topics will become part of technology education?

3.b. What topics will disappear from technology education?

It can be read from the questions that rather than "technology education", we used a term similar to STEM but more common for our experts. This made it more recognisable, particularly for the experts involved in primary education.

Methodology

In the first round, the experts formulated trends and topics in their own words. This resulted in a total of over 280 answers. As the experts already mentioned similar aspects, these were combined into 107 unique trends and topics divided over the six categories. Subsequently we already ranked the given answers according to their frequency.

In the second round, the experts were given the opportunity to change the order of the trends and topics based on the average order of the first round that was presented to them in the second round. The revised order was then again presented for revision to them in the third round after which sufficient consensus was established (a score was given to each trend and topic according to the order in which it appeared in the list and it was considered to be sufficient consensus when the interquartile range—the spread of the middle 50 per cent of the scores—was 3 or less because this means that the upper and lower score round the median—the value separating the higher half from the lower half of the scores—differs less than two places in the order of importance; here we followed the indications used by Heiko, [2012]). The fact that consensus was reached even though the experts were from two countries shows that our impression that the two countries show comparable developments was correct.

Contrary to the USA study we did not submit the questions to a large number of respondents as in a survey, but to a small number of selected experts, as in most Delphi studies. The group of experts was a mix of teachers, teacher educators, pedagogical supporters, and policy makers. All the experts are in the field of technology education, but for primary education, science education and technology education are not separate subjects. Some of the experts for secondary education had a background in science education also. In that sense, the experts often also connect to STEM. There was also a spread of experts over primary and secondary education.

Table 1. ***Number of Respondents***

Respondents	Round 1	Round 2	Round 3
The Netherlands	11	4	2
Flanders	17	9	5
Teachers	8	2	1
Teacher educators	11	6	3
Pedagogical support	4	2	1
Policy makers	4	2	2
Unknown	1	1	
Total	28	13	7

From Table 1 it can be seen that the number of respondents dropped with each round. This means that we can be fairly confident in the content of the factors that were mentioned but less of the status of the consensus. Statistically it is a consensus indeed but with a very low number of respondents left over.

Results

First, in this section, the outcomes for each of the six research questions will be presented briefly (in terms of lists of most important factors and topics), and then in the conclusion and discussion session we will build the overall picture of what the experts have brought forward.

In Table 2 the outcomes of the six research questions have been combined to get an overview of all factors and topics brought forward by the experts.

The higher topics were ranked (see numbering in Table 2), the more often consensus was reached. In Table 2 one can see that this is always the case for the top three topics, and sometimes even for the top five or six. This resulted in both the second and third round in a clear image of the most prominent topics for all factors (current and future positive or negative impact and issues). For the topics ranked below this top was less consensus on their relevance or importance. This, however, isn't very surprising or worrying as these topics weren't ranked very high. One can say that the experts differ a bit in vision, what helps and is valuable to discuss, but on the most important aspects they all agree.

Table 2. ***Factors and Impacts Combined***

	Positive (factor)/increasing (topic)	Negative (factor)/decreasing (topic)
Current impact factor	1. Enthusiasm of technology teachers. 2. Increasing attention for inquiry- and design-based learning. 3. The new national STEM standards.	1. Lack of knowledge and skills of teachers. 2. Negative image of technology education at schools. 3. Little or no focus on STEM in primary education. 4. Little cooperation between subjects resulting in isolated position of technology teacher.

Future impact factor	1. Better teacher education for technology teachers. 2. The introduction of STEM-specialised teachers. 3. Cooperation with knowledge institutes. 4. A new vision on STEM by the government (more integrated education). 5. Modernisation of the curriculum with STEM as a key competence.	1. Time pressure for technology teachers. 2. Fragmentation of STEM subjects. 3. Uncontrolled labelling of activities as "STEM".
Topic in curriculum	1. Project-based and explorative activities with practical relevance. 2. Iterative design cycles with increasing complexity. 3. More multidisciplinary and integrated STEM education. 4. ICT-related topics (AI, VR, robotics and programming). 5. Sustainability, environment, and climate. 6. Health (less prominent in the list).	1. Design work and classroom experiments with a fixed sequence of steps without explanation of the rationale for these steps. 2. Contextless and abstract teaching. 3. Tinkering and craft.

Conclusion and discussion

Table 2 suggest that there are three main issues to which the experts refer: teachers' enthusiasm, the status of technology education and the curriculum.

On the one hand, the enthusiasm of teachers is seen as the most positive impact factor for technology education. On the other hand, the fact that there is a shortage and that the teachers there are lacking knowledge and skills is a serious threat for technology education. Also, the fact that there is a time pressure on teachers is problematic. For the future the experts have high expectations of the emergence of new teachers that have been trained as specialised STEM teachers.

The second issue is the status of technology education. Experts expressed their concern that this status is still low, despite all the efforts made in the past decades to develop a fully up-to-date subject in which making is no longer the most important activity but designing and the social aspects of technology are also important elements of the curriculum. This image does not get better of course when, e.g., the government put the label "STEM" on all sorts of activities without distinguishing between high quality teaching and activities that are of inferior quality. For the future the experts see hope in the expectation that the role of tinkering and craft will be further diminished, and the curriculum will be more in line with other STEM subjects (more contextualised, more "trendy" topics like sustainability and ICT).

That brings us to the third issue, namely the curriculum. The experts are concerned about the fact that the position of technology education in the school curriculum is weak in certain respects. In the first place it does not have a good presence in primary education. Furthermore, it is often isolated which means that technology education does not gain from the higher status of other STEM subjects (particularly science education). For the future the experts have expectations of the new vision on STEM as promoted by government. If the idea is to have better connections between the STEM subjects, this will give technology education a better position. That, combined with the increased role of contemporary topics like sustainability and ICT, will likely improve the position of technology in the school curriculum.

For the Netherlands these outcomes can be understood in the context of the Curriculum.nu process that was described in Section 1. From the start of that process the position of technology was a concern and there was even a special committee to provide directions to the development teams for each of the learning areas as to how to include elements of technology in the standards they were about to develop. The end products of the development teams clearly contained traces of efforts to do justice to the role of technology in that learning area. As for the concern about teachers, for the Netherlands there certainly is a shortage, although more prominently for science than for technology. New teacher education programmes have been initiated for integrated STEM subjects like O&O (researching and designing) and NLT (nature, life and technology). A first effect is already visible in that the new teachers coming out of such programmes are strongly welcomed by Technasium schools and given high responsibilities in setting up curricula for O&O.

In Flanders, technology education was never a point of discussion over the past years. A broad consensus remains that technology must have a place in the curriculum from the age of two and a half till eighteen. Nevertheless, when looking at how it is placed in the curricula of primary and secondary education, there is a shift. In primary education, technology education gained some prominence, as before it was part of the lessons under the umbrella of “world orientation”, and since 2010 this subject is split up into “human and society” and “science and technology”. By doing so, technology became more visible in the primary curricula. Primary teachers often still struggle with the content, and despite their enthusiasm we experience a large need for workshops and the development of knowledge and skills in technology.

In secondary education, however, Flanders is currently in transition to a new structure and goals. STEM becomes more prominent as it is one of the eight domains students can choose. Technology, however, isn’t a main subject in this domain. The focus on more theoretical studies is often on science and mathematics. In labour market-oriented studies, we find the development of skills in electricity, mechanics, etc. a real theoretical study that (also) focuses on technology or engineering in the higher grades of secondary education is lacking. In the first year of secondary education the subject technology remains present, although it is difficult to find qualified teachers. The number of students in teacher training that choose technology education as a main subject is diminishing year by year.

It is also interesting to compare the results of the Low Lands study with the previous USA study. A clear communality is the concern about teachers, both in terms of availability and preparation in teacher education. The study in the USA did not mention the quality of teachers themselves. It would be too easy to conclude that USA teachers are better than teachers in the Netherlands and Flanders, particularly because for both contexts the quality of teacher education was mentioned as a reason for concern. The status of technology education is another common concern for the two contexts. Technology education is still not acknowledged as a subject of high relevance, probably due to its history in craft. A difference between the two contexts is that funding is not mentioned as a reason for concern in the Low Lands, whereas it was mentioned as a reason for concern in the USA. This can probably be explained by the fact that in the past the government has provided a fair budget for schools to set up a technology education classroom with good equipment. Teachers get an annual budget per pupil to purchase materials and replacement tools. The positive expectations expressed in the USA study concerning increased attention for inclusion and equity are absent in the Low Lands study. This can be explained by the fact that the Low Lands, generally speaking, have a stronger multicultural tradition than the USA (race segregation, for instance, only belong to a period far back in history) and a stronger social tendency for acceptance of alternative gender identities compared to the more traditional ones.

Concluding remarks

Both the USA and the Low Lands study have shown that a consultation of experts on the present and future of technology education as an element of STEM yields results that can be well interpreted from the national contexts of the studies. Both studies show that there are serious concerns for the future but also that there are opportunities to safeguard the future of technology education in the context of STEM. Both studies show that a better connection of technology education with the other STEM subjects can enhance the position of technology education in the curriculum. Teachers, however, are always a crucial factor and the availability and education of them is a continuing concern.

References

Ardies, J., & Boeve-de Pauw, J. (2014). Techniek in het onderwijs: Een tweesporenbeleid. In I. Nicaise, B. Spruyt, M. van Houtte, & D. Kavadias (eds.), *Het onderwijsdebat* (pp. 43–69). Epo.

DeMaegt. J. (2017). *Roots van het vak techniek*,. University of Ghent

Hauttekeete, L. (2007). *Are you ready for the future? De visie van jongeren op technologie, industrie en werk.* Gent: Onderzoeksgroep MICT, 56 p

Heiko, A. V. D. G. (2012). Consensus measurement in Delphi studies: Review and implications for future quality assurance. *Technological Forecasting and Social Change*, *79*(8), 1525–1536. https://doi.org/10.1016/j.techfore.2012.04.013

Moens, G. (2008). TOS21 Technische Geletterdheid voor Iedereen. Vlaamse Overheid.

Moye, J. J., Reed, P. A., Wu-Rorrer, R., & Lecorchick, D. (2020). Current and future trends and issues facing technology and engineering education in the United States. *Journal of Technology Education*, *32*(1). https://doi.org/10.21061/jte.v32i1.a.3

Niiranen, S., Ikonen, P., Rissanen, T., & Rasinen, A. (2022). Current and future trends and issues facing technology education in Finland—Taking part in an international Delphi study. *Australasian Journal of Technology Education*, 8. https://doi.org/10.15663/ajte.v8i.88

Pedagogisch Bureau van het NSKO en NVKMO en NVKTO, (1971). *Het vernieuwd secundair onderwijs: observatiegraad*, 23, Archief Pedagogisch Bureau, Doos 157, omslag 215N, KADOC.

Scheys, M. (2015), STEM-kader voor het Vlaamse onderwijs, Departement Onderwijs en Vorming, Vlaamse overheid. https://publicaties.vlaanderen.be/view-file/18907

van Houte, H., Merckx, B., De Lange J., & De Bruyker, M. (2013). *Zin in wetenschappen, wiskunde en techniek*. Acco.

Vlaamse Overheid (n.d.), https://onderwijsdoelen.be/uitgangspunten/4820 Accessed on 2/10/2023