# The Influence of Schooling Environment: A Review of Instruments Used to Evaluate Students' Attitudes Toward Technology

**Abstract**

There are two difficulties associated with many previous evaluations of students' attitudes toward technology. First, most questionnaires focus on social and family environments, neglecting the schooling environment. Second, although some studies have considered the schooling environment, there has been no systematic review of these studies. To address this research gap, this study systematically identified articles from major education journals that have described students' attitudes toward technology. We reviewed these articles, evaluated the influence of the schooling environment, and created a valuable resource for future studies. Our review indicates that technological activities and advanced preparation by teachers can be beneficial in alleviating *boredom* as a key negative affective component of school environment. Equally important, our research indicates that technology classes, those that use modern technology as a basis for instruction, and those that stimulate higher-level thinking processes, can reduce the *difficulty* (a cognitive component of the schooling environment) of learning and improve students' conceptualizations of technology.

**Keywords:** Schooling Environment, PATT, Attitude Toward Technology, Cognitive, Design

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## Introduction

The maker culture, along with practical learning, has a long-standing history rooted in technology education and its predecessors (Industrial Arts, Manual Training, Manual Arts, Crafts Education). These traditions have contributed significantly to enhancing technology education schooling environments. Consequently, diverse approaches have been developed to cultivate positive attitudes toward technology among students. These approaches include experiential activities (Boeve-de Pauw *et al*., 2022; Purković *et al*., 2022;), and instructional approaches that encourage higher-level thinking (Boser & Daugherty, 1998; del Olmo-Muñoz *et al*., 2022). Approaches to technology education have moved beyond the integration of technology curricula and toward interdisciplinary courses that are now provided worldwide. The use of design-based learning (e.g., engineering design thinking) to help students develop the problem-solving abilities required for future challenges has become increasingly important (English, 2016; Hallström & Ankiewicz, 2023; Kelley &

Knowles, 2016). Consequently, school environments continue to play an important role in cultivating positive attitudes toward technology.

In many countries, the Pupils' Attitudes Toward Technology (PATT) instrument is used to assess the efficacy of technology education. In the early 1980s, Raat and de Vries (1985) developed the PATT instrument and used it to conduct an international study on students' attitudes toward technology. In their PATT workshop report, titled "What do girls and boys think of technology," they reported significant differences in attitudes toward technology by sex in 10 countries in Europe, Africa, Australia, and the Americas. Boys were generally more interested in technology and more aware of the diversity and importance of technology than girls. They were also more familiar with technology than girls. In addition, children's attitudes toward technology were apparently influenced by their parents' occupations. Therefore, that study highlighted the importance of social and family environments in shaping attitudes toward technology.

However, the survey by Raat and de Vries (1985) also noted that neither girls nor boys were likely to understand the relationship between technology and creativity and design. Thus, improvements to technology education within the schooling environment were needed. Because a comprehensive review may improve our understanding of the influence of the schooling environment, we formulated two research questions (RQs):

RQ1: What effect does the schooling environment have on student attitudes toward technology?

RQ2: What aspects of student attitudes toward technology can be improved by the schooling environments?

## Theoretical framework

### Philosophical models of technology

In Mitcham's philosophical model, attitudes toward technology are formed based on knowledge, volition, activities, and objects (Mitchum, 1994). In Figure 1, the individual is represented by the circle containing the human being, whereas the environment is represented by the activities and objects outside the circle. Subsequently, Ankiewicz *et al*. (2006) built on this philosophical framework by linking Mitcham's modes of manifestation of technology to the four components of general philosophy: epistemology, volition, methodology, and ontology (Fig. 2). This model also included the individual, who is represented by the human-being circle, and the environment outside the human being, which includes technological activities and technological objects. However, both models assumed that the individual (i.e., human being) and environment (i.e., activities) were linked by a unidirectional arrow, rather than bidirectional interactions.

**Figure 1.**

*Model wherein technology is manifested (Mitcham 1994:160)*

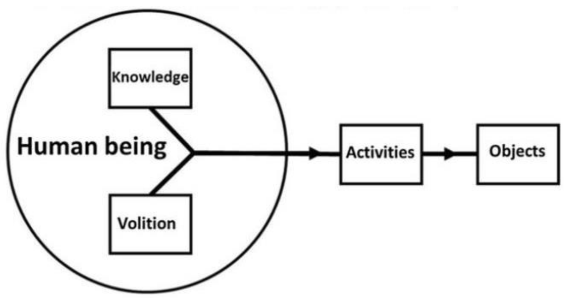
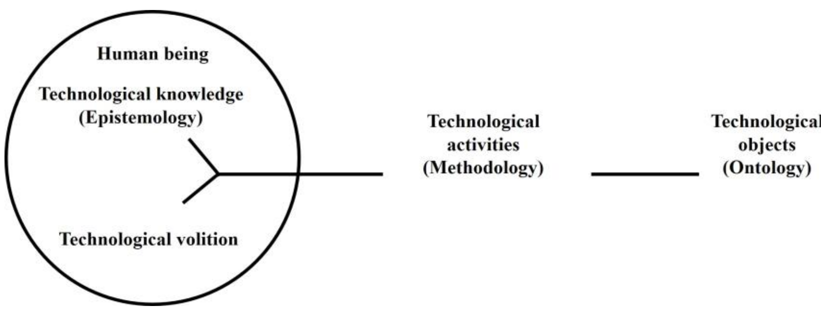



**Figure 2.**

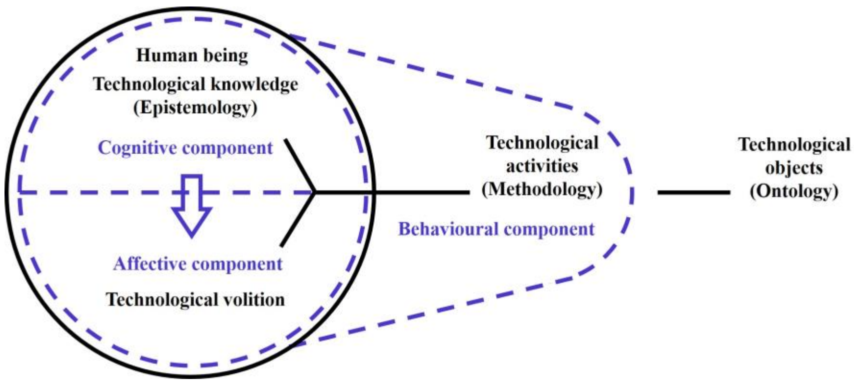
*Ankiewicz's modes of manifestation of technology to the Mitcham's model (Ankiewicz et al., 2006)*




More recently, Ankiewicz (2019) introduced the concept of superposition, also based on Mitcham's philosophical model of technology. Here, the human being's cognitive component influences the affective component, together forming the behavioral component. The human being's technological knowledge and volition generate technological activities that produce technological objects (Ankiewicz, 2019; Fig. 3). That study improved Mitcham's model by linking volition to axiology and adding arrows, as shown in Figure 4 (Hallström & Ankiewicz, 2023). This model emphasized the interactions between human beings and their environment.

**Figure 3.**

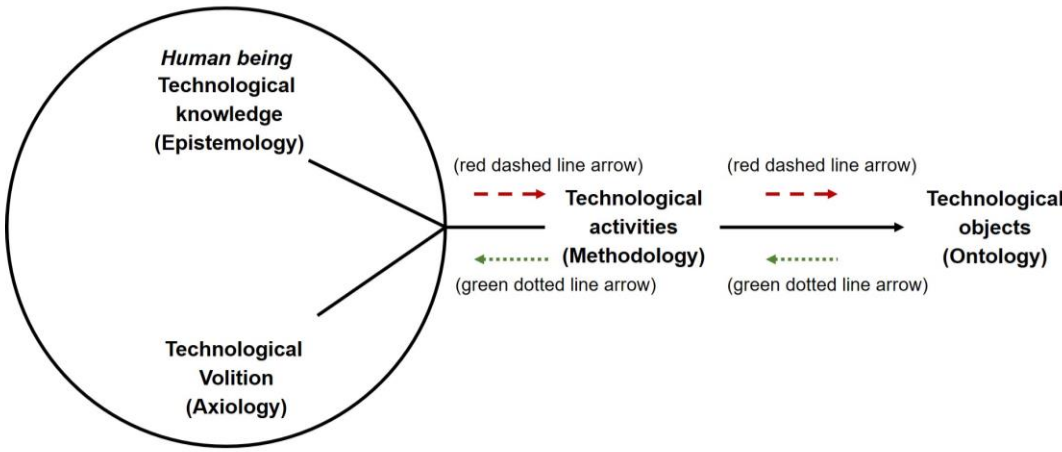
*Superposition of the traditional approach to attitudes and Mitcham's philosophical framework of technology (Ankiewicz, 2019)*




In the technology models described in Figure 3, the importance of interactions between individuals and their environments has increased over time. In the two earlier models (Figures 1 and 2) described by Mitcham (1994) and Ankiewicz *et al*. (2006), the human-being circle only contained knowledge and volition, whereas the environment outside the circle included activities and objects created by human beings. Technology is viewed as a type of environment that is created by individuals. Ankiewicz (2019) subsequently extended the human-being circle to technological activities, thereby considering technological activities as behavioral components of human beings (Figure 3).

**Figure 4.**

*Adaptation of Mitcham’s model to include “axiology” and directional arrows (Hallström & Ankiewicz, 2023)*




In the model shown in Figure 4, Ankiewicz (2019) added arrows to show that technological activities are affected by human beings (red dashed line arrows). Similarly, the affective and cognitive components of human beings are affected by technological activities (green dotted line arrows). Environments include technological activities, which are important in shaping attitudes toward technology. Specifically, the advent of diverse pedagogical approaches, diverse instructional strategies, and various new technologies has resulted in taught courses becoming increasingly important in shaping the attitudes of learners. Given the newly recognized importance of interactions between individuals and their environment, for this study, the schooling environment is considered a dimension critical to better understanding how the environment might affect student attitudes toward technology.

**Student technology attitudes and their relation to the environmental, cognitive, affective, and behavioral components**

Since the development of the PATT instrument in 1985, it has subsequently been used in many studies of attitudes toward technology and in various countries around the world (Ardies *et al*., 2013; Bame *et al*., 1993; Becker & Maunsaiyat, 2002; Svenningsson *et al*., 2022; Van Rensburg *et al*., 1999; Voke *et al*., 2003). Most previous studies of students' attitudes toward technology have been based on the following seven subscales: interest, gender roles/role patterns, consequences/importance, boredom/tediousness, difficulty, curriculum, and careers in technology. *Concept of Technology* questionnaires or essays have also been used to help researchers and educators understand and discuss the influence of cognitive, affective, and behavioral components of students' attitudes toward technology (Ankiewicz, 2019a; Ankiewicz, 2019b; Svenningsson et al., 2022). Additionally, a study conducted by Tzeng & Yu in 2023 analyzed 23 articles reporting on students' attitudes toward technology and classified the areas of attitudinal influence into cognitive, affective, behavioral, and environmental components. Their findings revealed that studies investigating the environmental component are most often focused solely on the home.

Many questionnaires that evaluate attitudes toward technology focus on social and family environments, with less emphasis on the schooling environment. Furthermore, although some studies have discussed the schooling environment (e.g., school region and participation in or experience of technology courses; e.g., Boeve-de Pauw *et al.*, 2022; Boser & Daugherty, 1998; del Olmo-Muñoz *et al.*, 2022; Householder & Bolin, 1993; Purković *et al.*, 2022), no relevant systematic reviews have been produced to guide the future implementation of technology curricula.

According to Ankiewicz (2019b), the subscales of the PATT-NL and PATT-USA instruments are all measures of the affective component. By contrast, Svenningsson *et al*. (2022) proposed that the cognitive component included an individual's attitude toward psychological objects such as their beliefs and thoughts about technology (e.g., gender role, importance, and difficulty). Moreover, the affective component includes the individual's positive or negative emotional responses to technology, such as interest and boredom. Furthermore, behavior may be motivated by intentions, which are influenced by affective and cognitive components (e.g., career aspirations). Consequently, the PATT-Netherlands (NL) and PATT-USA instruments do not clearly define the relationship between their subscales (i.e., relationships between interest, gender roles/role patterns, consequences/importance, difficulty, curriculum, and careers in technology) and the cognitive, affective, and behavioral components of attitudes. Only questions or tests regarding the *concept of technology* can be directly considered assessments of the cognitive component (Ardies *et al*., 2013; Bame *et al*., 1993; Volk & Yip, 1999).

Based on the perspectives of Ankiewicz (2019b) and Svenningsson *et al*. (2022), we separated the instruments that evaluated students' attitudes toward technology into six subscales and classified them into cognitive, affective, and behavioral components (Table 1). Svenningsson *et al*. (2022) proposed six subscales (by omitting curriculum), and all subsequent analyses in this study are based on that framework because this facilitates the classification of subscales into cognitive, affective, and behavioral components.

**Table 1.**

*Relationships between students' attitudes toward technology subscales and the cognitive, affective, behavioral components of attitude*

| | | Cognitive beliefs | Affective emotions | Behavioral intention |
|---|---|---|---|---|
| | | (based on Svenningsson *et al*., 2022) | | |
| Affective (based on Ankiewicz, 2019) | Gender role/ role pattern | X | | |
| | Importance/consequences | X | | |
| | Difficulty | X | | |
| | Interest | | X | |
| | Boredom/ tediousness | | X | |
| | Career aspiration | | | X |

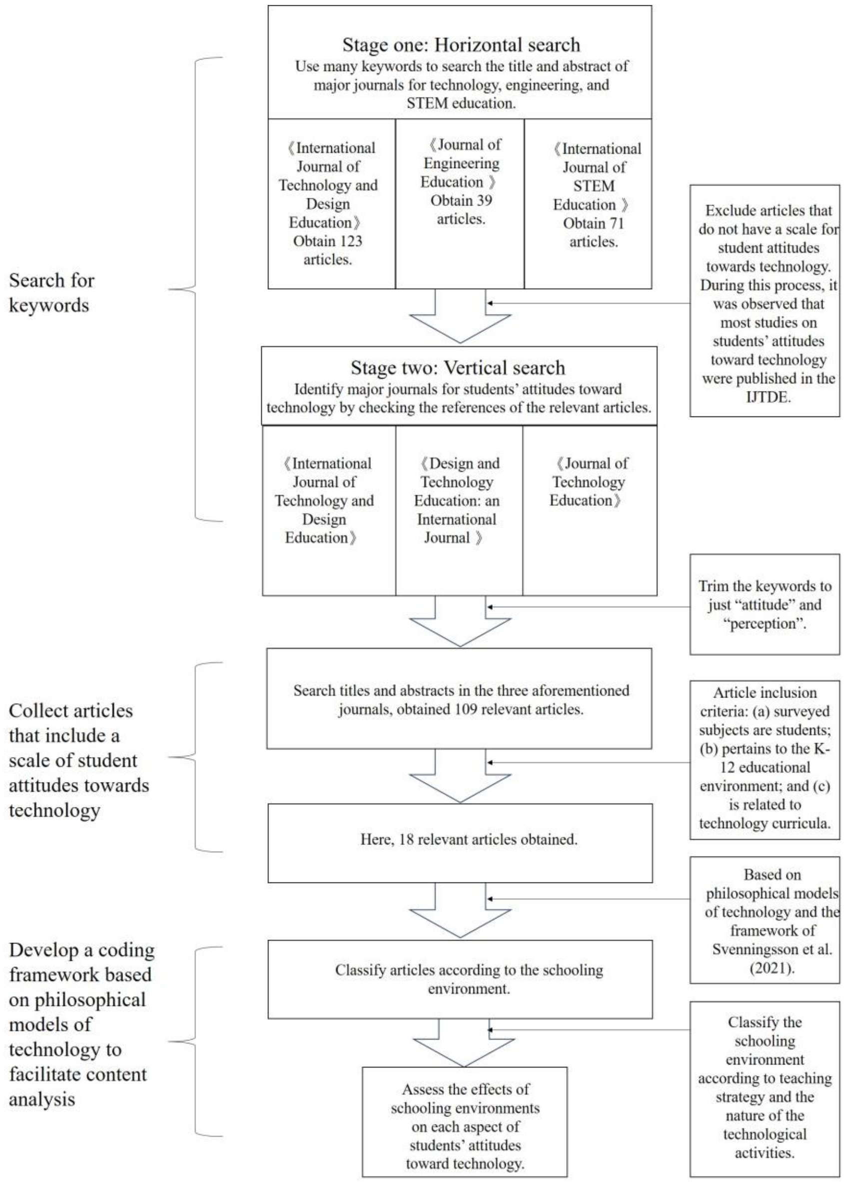
Data sources: Ankiewicz (2019b) and Svenningsson *et al*. (2022)

## Method

Using the procedure described by Gao *et al*. (2020), we conducted a systematic review of the literature based on the following three steps: searching the literature using keywords, identifying articles that included a scale for students' attitudes toward technology, and analyzing the content of these articles using a framework based on philosophical models of technology proposed by Ankiewicz (2019) and Svenningsson *et al*. (2022). Figure 5 presents a flow chart describing the systematic review procedure.

**Figure 5.**

*Flow chart: Procedure followed for conducting systematic review*



**Keyword search**

The first stage of the keyword search process was a horizontal literature search. Technology-themed integrated courses are internationally popular in technology education, and studies on students' attitudes toward technology are often published in major science, technology, engineering, and mathematics (STEM) education journals, such as the *International Journal of Technology and Design Education* (IJTDE), the *Journal of Engineering Education*, and the *International Journal of STEM education*. Therefore, we searched title and abstract fields for articles published in these journals within the preceding 10 years using the following keywords: attitude, beliefs, efficacy, motivation, interest, and perceptions. We identified 123, 39, and 71 articles from the three journals listed above, respectively. The majority of studies describing students' attitudes toward technology were published in the IJTDE. Although there were articles in the other two journals that discussed student attitudes, none of those publications used a scale developed from PATT instruments.

The second stage of the keyword search process was a vertical literature search. Drawing from the reference lists of articles reviewed in the IJTDE, we identified two additional relevant journals: *Design and Technology Education: An International Journal* (DTEIJ) and the *Journal of Technology Education* (JTE). Based on these results, we then systematically analyzed content from the IJTDE, DTEIJ, and JTE from both the last 10 years and those published earlier. Implementing this adjustment made our systematic-review procedure more robust.

PATT research has been conducted beginning as early as 1985, with results published across the decades since. And though the JTE was one of the first journals to publish PATT studies, it was not included in the initial horizontal literature search because during that search it was observed that technology-themed integrated courses were very popular in the STEM education journals internationally. However, through the first stage, we found that most attitude articles were concentrated in the IJTDE. In light of this, during the second stage we broadened the search for articles to include the IJTDE, DTEIJ, and JTE from both within and beyond the last 10 years.

*Identification of articles that included a scale measuring students' attitudes toward technology*

During the keyword search in the second stage of the keyword search process, we found that the initial selection of keywords could be trimmed, because the search results often overlapped. As a result, keywords were trimmed to include only *attitude* and *perception* for the final searches in the selected journals IJTDE, DTEIJ, and JTE. Thereafter, the titles and abstracts of these articles were inspected to exclude redundant articles, resulting in 109 articles being identified: 82 from the IJTDE, 20 from the DTEIJ, and 7 from the JTE.

The final criteria used in selecting articles for analysis were the following: the survey participant sample was comprised of students, the research environment was K-12 education, the curriculum was a technology course, and articles needed to include a scale developed from PATT instruments. Articles that did not survey K-12 students' attitudes toward technology and did not discuss schooling environment were excluded (e.g., studies that surveyed teachers, only discussed social and family environment, or reviewed other articles on students' attitudes toward technology). This process resulted in a total of 18 articles being selected for content analysis.

*Content analysis: Coding framework*

Content analysis was performed following selection of the 18 articles. The authors carefully read each one and recorded details (i.e., author names, journal name, year of publication, students' attitudes toward technology scale/subscale, design of questionnaire items, and main findings) in a table using Excel software (Microsoft Corporation). Based on these reviews a coding framework (Table 2) was constructed, based on the philosophical models of technology, that would be used to evaluate the subscales reported on in each article.

**Table 2**

*Coding Framework*

| | **Components of Schooling Environment** | | | |
|---|---|---|---|---|
| **Cognitive Beliefs** | Code G:<br><br>Gender Role/Role Pattern of cognitive components | Code M:<br><br>Importance and Consequences of cognitive components | Code D:<br><br>Difficulty of cognitive components | Code Co:<br><br>Other subscales of cognitive components |
| **Affective Emotions** | Code I:<br><br>Interest of affective components | Code B:<br><br>Boredom and/or tediousness of affective components | Code Ao:<br><br>Other subscales of affective components | |
| **Behavioral Intentions** | Code A:<br><br>Career aspirations of behavioral components | Code Bo:<br><br>Other subscales of behavioral components | | |

## Results

### Main findings

*Quantitative Findings*

All 18 articles analyzed included discussions on the school environment, but only five had questionnaire items related to participation in technology curricula (Table 3). Most of these items were quantitative questionnaire items, and there was only one item in each article. Furthermore, these items were all similar because they were generally concerned with curriculum options such as attending design and technology (D&T) classes in school or taking technology-oriented courses (article nos. 3, 4, 6, 16, and 17). One article (No. 6) used first and second grade to assess differences in students' attitudes toward technology.

**Table 3.**

*Article Analyses: Schooling Environment Assessment Methods*

| Assessment Method | | Article No. | Articles/Method |
|---|---|---|---|
| Quant | Qual | | |
| Questionnaire | | 3, 4, 6, 16, 17 | 5 |
| | Interviews | 8 | 1 |
| | Experimental design/ Intervention | 2, 9, 11 | 3 |
| | Text Descriptions:<br>- school region<br>- tech ed availability<br>- student experiences<br>- participation in technology curricula | 1, 5, 7, 10, 12, 13, 14, 15, 18 | 9 |

*Qualitative Findings*

Thirteen articles used qualitative methods to assess the schooling environment. Of these, only one article (No. 8) used interviews and three others (No. 2, 9, 11) used experimental design/intervention. It is worthy to note that nine articles used descriptive text as qualitative methods for assessing the schooling environment. These articles discussed the school region, availability of technology education, and details regarding student experiences or participation in technology curricula as a method for assessing the influence of technological activities within schooling environments on students' attitudes toward technology. Given the diversity of quantitative and qualitative measures used among the 18 articles analyzed, there was a lack of consistency in the methods used to assess students' attitudes toward technology based on the influence of technological activities within schooling environments.

Of the 18 articles selected for analysis, many discussed the influence of schooling environment by analyzing their subscales. Based on our coding framework (Table 2), Table 4 presents a summary of how each article characterized the cognitive, affective, and behavioral components. Those articles marked with an asterisk used self-defined subscale names or simple questionnaire items derived from mainstream PATT instruments.

**Table 4**

*Articles incorporating schooling environment in their subscales*

| | Articles per Schooling Environment Subscales | | | |
|---|---|---|---|---|
| Cognitive Beliefs | Code G<br><br>4, 6, 8, 9, 11, 14, 15, 16, 17<br><br>Subtotal = 9 | Code M<br><br>4, 6, 8, 9, 11, 14, 15, 16, 17<br><br>Subtotal = 9 | Code D<br><br>4, 6, 8, 9, 11, 14, 15, 16, 17<br><br>Subtotal = 9 | Code Co<br><br>1*, 2*, 3*, 5*, 7*, 10*, 12*, 13*, 15*, 16*<br><br>Subtotal = 10 |
| Affective Emotions | Code I<br><br>4, 6, 8, 9, 11, 14, 15, 16, 17<br><br>Subtotal = 9 | Code B<br><br>6, 8, 9, 11, 14<br><br>Subtotal = 5 | Code Ao<br><br>1*, 2*, 3*, 7*, 10*, 13*<br><br>Subtotal = 6 | |
| Behavioral Intentions | Code A<br><br>4, 6, 8, 9, 11, 14, 16, 17<br><br>Subtotal = 8 | Code Bo<br><br>1*, 3*, 7*<br><br>Subtotal = 3 | | |

Note: see Table 2 for code descriptions
Total number of articles n=18
* = articles using self-defined subscale names or simple questionnaire items derived from mainstream PATT instruments

**RQ1: Effects of schooling environments on students' attitudes toward technology**

*Experience of participating in technology classes*

To answer RQ1 (*What effect does the schooling environment have on student attitudes toward technology?*), we analyzed the articles addressing student experiences in technology classes written by Ardies *et al*. (2015), Becker and Maunsaiyat (2002), and Volk *et al*. (2003) (No. 6, 16, and 17). Our focus was on the *curriculum option* items such as taking D&T classes in school or taking technology-oriented or non-technology-oriented classes. Ardies *et al*. (2015) surveyed 12- and 13-year-old Belgian students who attended a two-hour technology class once every week. Students who were taking additional external (outside of school) technology classes scored higher than only those students not coded M (importance/consequences) of the Cognitive Beliefs components. Becker and Maunsaiyat (2002) surveyed 13- to 15-year-old Thai students attending industrial arts or technology education courses. They found that students who had taken these classes scored significantly higher than those who had not taken such classes in the Affective Emotions components of interest, and the Cognitive Beliefs components of gender roles and importance/consequences. In a survey involving students in Hong Kong, Volk *et al*. (2003) found that girls who attended D&T classes for three years exhibited higher scores in the Cognitive Beliefs components of role pattern, difficulty, consequences, and school curriculum than those who only attended D&T classes for one year. However, the more traditional industrial arts program was beneficial for girls' career aspirations (Behavioral Intentions components). Notably, the more innovative technology education program included more problem solving and group activities, whereas the more traditional industrial arts program included craft-based activities and focused on skill development.

Our analysis indicated that the experience alone of participating in technological activities was insufficient to differentiate the effects of the schooling environment on students' attitudes toward technology. This finding, which is likely the result of participation conditions (e.g., duration of participation, the nature of the technology activities, and the instructional approach) varying widely among the studies, is insufficient evidence to fully answer RQ1. In light of this, the duration of participation, the nature of technology activities, and the instructional approach used in each technology class must be considered independently in any comparisons so as to isolate the effects of activities on students' attitudes toward technology.

*Duration of participating in technology classes*

Further independent analysis of only the *duration* of participation as a participation condition was conducted in an attempt to better answer RQ1. Analysis of select articles written by Volk, and Yip (1999), Svenningsson *et al*.

(2018), and Hendley *et al*. (1996), was conducted in an effort to confirm findings from the preliminary analysis. The Volk, and Yip (1999) article (No. 4) reported on the results of their administration of the PATT-Hong Kong survey involving 3,381 junior secondary students aged 14–15 years in Hong Kong, Their research found that students who had taken D&T classes or technical subjects in school did not exhibit more positive attitudes toward technology than those who had not taken these classes. The Svenningsson *et al*. and Hendley *et al*. articles (No. 3 and 8) also noted that it was difficult to change students' concept of technology within a few years following implementation of a new curriculum. Svenningsson *et al*. surveyed 12- to 15-year-old Swedish students several years after the implementation of the 2011 national curriculum. They found that students' conceptualizations of technology were predominantly influenced by experiences outside school. Similarly, Hendley *et al*. administered the PATT Short Questionnaire (PATT-SQ) in South Wales five years after a new national curriculum had been implemented. Their research found that students tended to use terminology that predated the national curriculum to describe elements related to technology (e.g., sewing instead of textiles, and Home Economics or Cookery instead of Food Technology). Hendley *et al*. speculated that this may have been because teachers had not yet changed their approach when teaching the new subject.

Additionally, results from various small-scale PATT surveys administered by Ardies *et al*. (2015), Becker and Maunsaiyat (2002), and Volk *et al*. (2003) all indicated that participation could significantly improve attitudes toward technology. However, the large-scale administrations of PATT surveys and in-depth interviews conducted by Volk and Yip (1999), Hendley *et al.* (1996), and Svenningsson *et al.* (2018), contradicted the small-scale PATT surveys by identifying important limitations. Specifically, findings reported in the Hendley *et al.* and Svenningsson *et al.* articles indicated that when the implementation of new technology curricula failed to change conceptualizations of technology, then the reasons are most likely related to the teaching approach used by the teacher.

As was the case with analysis of participation *experiences*, analysis of *duration* of participation as a participation condition produced insufficient evidence to answer RQ1. Therefore, our investigation of the influence of schooling environments on students' attitudes toward technology continued with an independent analysis of the nature of technological activities, as well as the instructional approaches teachers used. Among the 12 articles that described school regions and participation in technology classes, we conducted keyword searches for those that discussed the *nature* of the technological activities and instructional approaches. Five articles (No. 2, 9, 11, 12, and 15) satisfied these criteria.

*Nature of the technological activities*

Boeve-de Pauw *et al*. (2022) administered the PATT survey to study the effects of an experience involving technology on Belgian students just before, three days after, and three weeks after engaging in a one-day experiential technological intervention (article No. 9). The intervention involved students in grades five to six interacting with technology materials and exhibits within a high-tech truck, as an approach to helping them understand how technology can be used to solve problems in industry and society. The PATT questionnaire was administered to 1,496 elementary school students aged 10–12 years just before, 3 days after, and 3 weeks after participating in a one-day technology experience activity. Of the 75 teachers at the targeted school, 50 participated in preparing the intervention training sessions. After confirmatory factor analysis, *t*-test and effect size (Cohen's d) were calculated, revealing significant differences. One week and three weeks following the intervention, student PATT scores showed significant improvements in gender, consequences, interest, boredom, and career aspirations aspects of their attitudes toward technology. Specifically, this short-term technology engagement intervention improved all but one aspect (difficulty) of student attitudes. Furthermore, a significantly positive influence on boredom (affective emotion aspect) was detected and attributed to the advanced instructional preparation of teachers.

To better understand why a one-day experiential technological intervention had a negative impact on *difficulty*, we analyzed article No. 12 by Purković *et al*. (2022). This study used an extension of the PATT Short Questionnaire (PATT-SQ) to survey 2,205 Croatian students in grades five to eight who were taught Technical Culture among other subjects (e.g., informatics, physics, chemistry, biology, and information and communication technology). The activities in these curricula generally occurred outside regular classes and depended on enthusiastic teachers or the priorities adopted by individual schools. The students often participated in these activities for enjoyment without understanding their potential applications. These were long-term experiential technology curricula (compare to a one-day activity, Boeve-de Pauw et al., 2022) and were not based on practical or design activities. Findings revealed that although many students participated in the experiential technology curricula, their understanding of technology remained limited, and nor were they well equipped to apply the technology to real-life situations. This may lead to students having feelings of antipathy toward technology, particularly if they also have a poor understanding of the underlying technological concepts. In such instances, students who engage in purely experiential technological activities may have fewer opportunities for enactive learning and reflection. As a result, this may cause students to become more confused about technology and increase their difficulty beliefs.

Based on our independent analysis of the *nature* of the technology activities as a participation condition, the evidence supports an affirmative response to

RQ1. Experiential technological activities, when applied in schooling environments, were found to influence students' attitudes toward technology. These data showed that experiential technological activities can improve most aspects of students' attitudes toward technology. However, there were data also indicating they could not alleviate the *difficulty* (cognitive component) aspect. The main reason appeared to be associated with students lacking opportunities for active learning and reflection. This suggests that without a solid understanding of technological concepts, students are more likely to develop beliefs about increased difficulty. The lack of opportunity for active learning and reflection speaks to the need to investigate the instructional approaches teachers use as a schooling environment factor.

*Instructional approaches*

Del Olmo-Muñoz *et al*. (2022) (article No. 11) investigated the effects of an intervention into 2nd level primary education source courses for second grade students in Spain. The intervention consisted of five 45 min instructional sessions delivered once per week. The students were separated into two groups to compare the effectiveness of *plugged* vs. *unplugged* approaches to teaching computational thinking, as well as to evaluate the effect of these two approaches on student's attitudes toward technology. Toward the end of these courses, both groups performed plugged activities. The authors reported the unplugged approach had no significant effect on any aspect of students' attitudes toward technology. In contrast, the plugged approach resulted in significant and positive effects on the cognitive components of gender role and difficulty.

The data indicated that participation in technology classes coupled with the use of modern technologies (such as computers and videos) and higher-level thinking processes (such as computational thinking, critical thinking, and problem solving) had positive effects on gender role and difficulty. We also made two other important observations. First, they found large gender-based differences among seven- and eight-year-old Spanish students' attitudes toward technology before the class, with boys being much more technologically inclined and having greater career aspirations than girls. The unplugged course reduced the gender-based gaps in interest and career aspirations, whereas the plugged course reduced the gap in interest but widened the gap in career aspirations. In other words, the unplugged approach was not necessarily poorer than the plugged approach. Furthermore, the plugged approach had significant positive effects on gender role and difficulty, with gender role improving only in boys but difficulty improving in both boys and girls (after the courses, girls reported *not difficult* instead of neutral, whereas boys reported neutral instead of difficult).

Boser and Daugherty (1998) in article No. 15 examined the effects of technology education programs at four different middle schools located in one state of the United States on the attitudes seventh grade students hold toward technology. The PATT-USA questionnaire was administered the first and last weeks of a 9-week program. At each of the participating schools one of the following four teaching approaches was used: an industrial arts approach (subject matter organized to improve understanding of all aspects of industry and technology), an integrated approach (instruction that incorporates other disciplines to show how technology is an integral part of other disciplines), a modular approach (individualized, self-paced, action-based units of instruction that allow students to use current technologies to learn independently), and problem-solving approaches (instructional approaches that emphasize critical thinking). Research results found that the four approaches had no significant effect on gender role or interest aspects within the Cognitive Beliefs category. In this category as well, the problem-solving and integrated approaches were found to have significant positive effects only on difficulty and consequences, respectively (career aspirations were not discussed).

Two further observations were recorded. The authors found that none of the instructional approaches improved interest or gender role among the boys or girls, in contrast to the results reported by Boeve-de Pauw *et al*. (2022) and del Olmo-Muñoz *et al*. (2022). Furthermore, the technology program was not described in detail (e.g., whether computers were used in teaching or whether technological activities were based on practical or design activities). Presumably, the problem-solving approach employed higher-level thinking.

The analysis of another article (No. 2) provided a possible explanation. Householder and Bolin (1993) compared students taught in a traditional classroom setting (the comparison group) with students taught using technology such as video production (the experiment group). Students in the experiment group exhibited significantly more positive attitudes toward technology, as well as increased achievement scores in technology classes. Notably, both the Householder and Bolin as well as the del Olmo-Muñoz *et al*. (2022) article reported technological tools were used for teaching and incorporated higher-level thinking processes. What can be inferred is that using technological tools for teaching can have beneficial effects on difficulty (Cognitive Belief category) and achievement scores. However, if higher-level thinking processes are incorporated into isolation, such as in the problem-solving approach described by Boser and Daugherty (1998), a technology program may have beneficial effects on difficulty without improving students' conceptualizations of technology.

## RQ1 and RQ2 Summary

Research Question 1 (RQ1) asked *What effect does the schooling environment have on student attitudes toward technology?* and Research Question 2 (RQ2) asked *Can schooling environments improve the various aspects of students' attitudes toward technology?* An initial analysis of the 18 articles found that the experience of participating in technological activities alone was insufficient to differentiate the effects of schooling environment on student attitudes toward technology. Further differentiation would require independent analyses of the *duration* of participation, the *nature* of the technological activities, and the *instructional approach* in order to isolate the effects of activities on attitudes students hold toward technology.

Analysis of *duration* as a participation condition produced insufficient evidence to affirmatively answer RQ1, which meant it was not possible to answer RQ2. Independent analysis of the *nature* of the technological activities to answer RQ1 affirmed that experiential technological activities can both effect and improve most aspects of student attitudes toward technology, but that they could not alleviate the difficulty aspect. In analyzing the *instructional approach*, results showed there was no effect on gender role or interest, while the problem-solving and integrated approaches had significant positive effects on the difficulty and consequences aspects. Therefore, the application of certain instructional approaches will effect (RQ1) some aspects of student attitudes toward technology – applying instructional approaches in schooling environments does influence students' attitudes toward technology. However, with respect to instructional approaches, RQ2 could not be definitely answered. Only those approaches using technological tools for teaching and incorporating higher-level thinking processes were found to improve the difficulty aspects of students' attitudes toward technology and students' conceptualizations of technology.

## Discussion and Conclusions

Our analysis shows that a simple appraisal of the effects of schooling environments on students' attitudes toward technology is insufficient to understand the influence of specific technological activities. Specifically, our analysis highlights that the nature and instructional approach associated with each technological activity must also be independently considered. Results of analysis indicate that an experiential technological activity can have positive effects on students' attitudes toward technology, and that advanced preparation by teachers is particularly beneficial for alleviating the aspect of boredom. However, learning activities that do not include practical activities do not have beneficial effects on the aspect of difficulty. Technology classes combined with the use of modern technologies as a basis for instruction and the stimulation of higher-level thinking processes were found to have beneficial effects on the aspect of difficulty and achievement scores. However, the use of instructional approaches that stimulate higher-level thinking alone will have a limited impact on improving students' conceptualizations of technology.

From our analysis of select articles presenting research addressing student attitudes toward technology, we can conclude the following:

(1) Schooling environments provide opportunities for students to explore their understanding of technology through appropriate activities. For

students to successfully engage in learning and adjust any cognitive misconceptions about technology, technology classes combined with the use of modern technology as a basis for instruction and the stimulation of higher-level thinking processes are better than experiential activities.

(2) Studies of the nature of technological activities suggest that students have high expectations of technology, and even a one-day experiences can improve attitudes toward technology. Furthermore, advanced preparation by teachers can alleviate “boredom.” However, if practical activities are not included, students may be unable to acquire feedback. This can have detrimental effects on “difficulty” for students who already have negative impressions of technology.

(3) Studies of the instructional approaches engaging students in technological activities showed that not every instructional approach was effective for improving students’ attitudes toward technology. However, approaches using modern technologies as a basis for instruction (e.g., computers and videos) and those that stimulated higher-level thinking processes (e.g., computational thinking, critical thinking, and problem solving) can decrease the difficulty aspect (i.e. cognitive beliefs) and improve learning (i.e. higher achievement scores and improved conceptualization of technology).

**Implications**

It is important to recognize that this research has limitations. Specifically, we did not consider some aspects of the schooling environment, such as teacher empathy, peer cooperation, and infrastructural support. These may also have an important influence on the attitudes toward technology students develop. Furthermore, given the selection criteria focused on attitudes toward technology rather than on attitudes toward engineering or STEM education (e.g., Tzeng, et al., 2024), our results may underestimate the influence of engineering and/or STEM education on the development of student attitudes toward technology.

Considering the evolving nature of technology, future research should be directed toward exploring how children's recognition and perceptions of technology have changed over the years since the original PATT study in 1985. At that time, technology was often perceived as materials-based, reflecting school experiences that revolved around woodworking, metalworking, cooking, needleworking, and the like. As computers began entering mainstream education in the mid-1980s and became integral to everyday educational practice by the 1990s and early 2000s, the perceptions of technology held by students shifted significantly. Thus, examining how these changing perceptions have influenced students' attitudes toward technology and assessing the impact of new perceptions on the role of schooling in shaping these attitudes could provide valuable insights. These considerations offer promising avenues for future studies, especially in the context of emerging technologies such as Artificial Intelligence (AI), which may well be further transforming how students understand and engage with technology.

Technological/Engineering design-based learning (T/E DBL) activities were not described in any of the articles we analyzed for this research. This may be a significant factor in accurately assessing the attitudes toward technology students hold today given the use of T/E DBL to help students cultivate the problem-solving skills they may need in the future has become increasingly important (English, 2016; Hallström & Ankiewicz, 2023; Kelley & Knowles, 2016). Furthermore, teaching technology education involves much more than the development of quality curricula because its goal is to design and integrate authentic activities that prepare students with the capacity to confront social and environmental problems in the real world. In light of this, future studies are needed to investigate aspects of T/E DBL curricula that may have positive effects on student interactions with technology. Such studies would have scholars exploring the impact of engaging students in T/E DBL on attitudes students develop toward technology. This line of research would seek answers to questions such as what kind of attitudes do students develop when participating in T/E DBL courses? Or possibly focus on the difference in attitudes students develop toward technology when engaged in the rational thinking of T/E DBL versus engagement in the creative thinking processes called for in art design-based learning. Of perhaps even greater importance would be research examining the influence of school environments on the attitudes students develop toward technology in conjunction with those learning theories that serve as the basis for explaining the relationship between technology attitudes and learning behaviors.

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