Reconstructing the Pupils Attitude Towards Technology-survey

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Abstract
In knowledge based economies technological literacy is gaining interest. Technological literacy correlates with attitude towards technology. When measuring technological literacy as an outcome of education, the attitudinal dimension has to be taken into account. This requires a valid, reliable instrument that should be as concise as possible, in order to use it in correlation with other instruments. The PATT instrument as developed in the nineties is an extensive survey that hasn't been revalidated over the last three decades. The Pupils' Attitudes Towards Technology (PATT) instrument was reconstructed and revalidated. The validation study was done in two major steps. First a pilot study with 250 students, followed by a main study with 3000 students. Different factors of the instrument were analysed on their internal consistency. Also the goodness of fit indices of the complete model were checked in a confirmatory factor analysis. This resulted in an instrument with six sub-factors and 24 items of attitude towards technology. The six factors are Career Aspirations, Interest in Technology, Tediousness of Technology, Positive Perception of Effects of Technology, Perception of Difficulty and Perception of Technology as a Subject for Boys or for Boys and Girls. The instrument is easy to use, reliable and validated. It opens a door to further research and evaluation of technology education.

Key words
attitude measurement, technology education, technological literacy

Introduction
In western countries technology, defined as any modification of the natural world done to fulfill human needs or desires, is gaining more interest as a subject in the school curricula. Different nations are investing in the development of teaching programs, research, and the establishing of platforms for the promotion of technology: e.g. the American National Assessment Governing Board is making a framework for Technology and Engineering Literacy in 2014 (National Assessment Governing Board, 2011); in May 2011 the Design and Technology Association of the United Kingdom wrote a manifesto to enlighten the importance of Design and Technology in the National Curriculum (Green, 2011); in the Netherlands a platform for Beta-science is established aiming to achieve a structural increase of 15% more pupils and students in scientific and technical education (Stichting Platform Bèta Techniek, 2004); and in many other countries governments are changing the national curriculum to add more technology into the comprehensive curriculum for students.

Although industries and policy makers think technology education is far more relevant these days than it was ever before, the public opinion about studying technology and technical jobs is not very positive (Johansson, 2009). The Organisation for Economic Cooperation and Development's (OECD) report on student interest in Science and Technology (S&T) Studies (OECD, 2008) states that although absolute numbers of S&T students have been rising, the relative share of S&T students among the overall student population has been falling. The report shows that encouraging interest in S&T studies requires actions to improve the image and knowledge of S&T careers. A report ordered by the department of education of the Flemish ministry (Van den Berghe, 2006) concludes that the image of technological studies and professions is rather low and that this contradicts the enthusiasm young people have for new technologies. This negative image is strengthened by some prejudices like: the working conditions in industrial environments are not interesting or even boring; and that these jobs imply hard and dirty labour, combined with moderate payment and bad hours. Moreover people tend to think that science and technology are hard and boring to study. These are widely spread ideas about technology within public opinion (Van den Berghe, 2006). Nevertheless systematic research about youngsters' attitudes towards technology and how these evolve during their school career is scarce.

For several reasons this is an important topic of research. First of all, research has demonstrated that the assumption that students who have a tendency to act positively towards a subject will have more interest in that subject (Krathwohl, Bloom, & Bertram, 1964). As such, it can be assumed that students exhibiting a positive attitude towards technology could be more likely to attain technological literacy through technology education because of a higher interest in the topic (Bame, Dugger, de Vries & McBee, 1993). So, further systematic research on attitudes towards technology is needed in order to relate it with technological literacy in general.

Reconstructing the Pupils Attitude Towards Technology-survey

An understanding of students' technological literacy and attitudes towards technology is necessary and perquisite to effective teaching about technology (Bame et al, 1993). Bame and colleagues (1993) point out that students have neither accurate nor complete knowledge of technology and attitudes are often biased. A good interpretation of students' attitude towards technology is therefore important. Attitude as a student outcome in itself is interesting to look at too. Students' interest, as an example of a sub-factor of attitude, in technology or a technological career is a valuable aspect when it comes to increase the number of students in STEM related studies and jobs as represented by the European Union (European Council, 2000).

Given the demand for research on attitudes towards technology, a clear necessity for a reliable instrument to measure attitude is present. Currently used instruments like ROSE (Relevance of Science Education) are often not specific in defining technology (Schreiner & Sjøberg, 2004). The ROSE study was focused on pupils' interest in science and technology, but there was made no specific distinction between science and technology. A more detailed exploration of the ROSE survey shows that less than 15% of the questions are, more or less, technology related. To our knowledge, the only instrument that has been explicitly made for the measurement of students' attitudes towards technology is the PATT-survey developed by de Vries (1988).

Since 1984 researchers are assessing students' attitudes towards technology by using the PATT instrument. Research with this instrument was first conducted in the Netherlands and is the first instrument specifically made for this purpose. Results in the Netherlands were so striking that an international extension of the research was the logical next step. In 1987 twelve countries decided to start using the PATT instrument or a part of it. A work conference was put together in the Netherlands to initiate the collaboration (Raat, Coenen-van den Bergh, de Klerk Wolters, & de Vries, 1988). Participants came from all over the world (e.g. India, Nigeria, Mexico, Australia but also West-European countries like France, UK and Belgium). In this report, due to the fact that not all participating researchers had the opportunity or knowledge to use statistical programs (e.g. SPSS), the suggestion is made to work on a more concise instrument. The idea was to investigate the possibilities of using a 'subset of factors' with maximum five items for each factor. Such an instrument yields many advantages like for example easier to apply, less time consuming, teachers can it use in the classroom, etc....

Many researchers state that the original PATT instrument is a useful instrument but often too long to implement in a study combining instruments. If one wishes to measure attitude and technological literacy among the same students time limitation is an issue that arises sooner than later due to practical and pragmatic circumstances. The major objection of the participants at the first PATT conference was that a high reliability is required, this off course need to be obtained at any time (Raat et al., 1987). However, since that first report stating a reduction might be worth investigating there has been no reported research concerning a possible reduction of the PATT instrument. Furthermore there has been a vast evolution in technology since the instrument was developed. Verifying if the items still represent the same factors is desirable.

In this paper the revalidation of this survey instrument to capture students' attitude towards technology is reported. The research focuses on the Flemish region (Belgium) in the heart of Europe because it appears to be an interesting case in this matter. Not only has Flanders to deal with the same specific problems as stated by the EU, it has also a well-developed framework about technological literacy based on international standards and frameworks, like the US Standards for example (ITEA, 2003; TOS21, 2008). Also has the Flemish autonomous region an educational curriculum that includes technology as a specific topic in the first grade of general secondary education (ISCED 2) for all students two hours on weekly basis. Therefore the focus is on the validation of the PATT to measure attitudes towards technology of 12-14 year olds (ISCED 2).

In the following sections the theoretical base will be described, followed by the methodology used in the research. Finally the results of the study will be presented in a concluding chapter.

Theoretical base

What are attitudes?

Attitude is a broad concept with different interpretations and definitions. In this research the concept that attitudes are psychological tendencies that are expressed by evaluating a particular entity with some degree of (dis)favour as defined by Eagly and Chaiken (1993) is used. This definition is commonly regarded as the most conventional definition (Albarracin, Zanna, Johnson, & Kumkala, 2005). Moreover, this definition is in line with the view of The Committee on Assessing Technological Literacy from the National Academies on attitudes (Garmire & Pearson, 2006) according to whom attitude towards technology is explicitly conceptualised as not to

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contain a cognitive dimension. What a person knows about a technological subject can however be correlated with attitude towards that subject.

How to measure attitudes?

Commonly, attitudes have been measured through the use of questionnaires that consist of Likert scale items where students are asked to respond to a number of statements. Each item is a component in a summated rating factor that consists of a number of opinion statements reflecting either a favourable or unfavourable attitude to the object (construct) being studied. The subject is then normally offered a five-point choice consisting of 'strongly agree/agree/not sure/disagree/ strongly disagree' to indicate their own feelings. Such items have been derived from the free response answers generated by students, which is the major justification for their validity. These open responses are then reduced to a set of usable and reliable items that have been piloted and further refined by statistical analysis to remove those that fail to discriminate (de Vries, 1988).

A related criticism that is highlighted in the literature (e.g. Bennett, 2001; Gardner, 1995; Osborne, Simons & Collins., 2003) is that attitude measures can in fact be of poor psychometric quality. In order to demonstrate this quality, an instrument needs to be statistically internally consistent and unidimensional. Many studies fail to provide evidence of these psychometric traits or wrongly assume that internal consistency implies unidimensionality (Gardner, 1995). It is therefore important to use a technique such as factor analysis to confirm the unidimensionality of a scale (Kind, Jones & Barmby, 2007).

A review study on attitudes towards science (Osborne et al, 2003) notes that they do not consist of a single unitary construct, but rather a large number of sub-constructs all contributing in varying proportions towards an individual's attitudes towards science (e.g. anxiety; value; motivation; enjoyment; achievement; fear of failure…). Hence, producing a unitary score on attitude is useless. The best that can be done according to these authors is to ensure that the components are valid and reliable measures of the constructs they purport to measure and look for the significance of each of these aspects. In a good instrument the different factors need to be internally consistent and unidimensional (Gardner, 1995). Internal consistency is often expressed with Cronbach's alpha reliability coefficient and is quoted in much of the research literature on the measurement of attitudes. However, while unidimensional factors will be internally consistent (since they all measure the same construct), it does not follow that internally consistent factors will be unidimensional (Osborne et al, 2003). This is because a factor may be composed of several clusters of items each measuring a distinct factor. In this situation, as long as every item correlates well with some other items, a high Cronbach's alpha will still be obtained. It is important that the unidimensionality of factors is tested using an appropriate statistical technique (e.g. factor analysis). If a factor does measure what it purports to measure, then the variance should be explained by a loading on a unitary factor.

The PATT instrument

The redefining and translation done by Bame and Dugger (1989) is the most recent big change of the originally Dutch instrument so far. This instrument is validated and often used in different countries around the world (Volk

Factor	Example items	Items
General interest in technology	I like to read technological magazines I will probably choose a job in technology	16
Attitude towards technology	I think machines are boring Technology causes large unemployment	8
Technology as an activity for both girls and boys	Boys know more about technology than girls do A girl can very well have a technological job	8
Consequences of technology	Technology is good for the future of the country Technology has brought more good things than bad	5
Technology is difficult	You have to be smart to study technology To understand something of technology you have to take a difficult training course	5

Table 1. Examples of the items in the original PATT factors and the number of items in each factor Bame and Dugger (1989)

and Ming, 1999; Ankiewicz & Van Rensburg., 2001; Becker and Maunsaiyat, 2002; Chikasanda, Williams, Otrel-Cass & Jones., 2011) after fitting the instrument to the specific regional context. Often the language of the test had to be changed but also context specific items had to be adapted (e.g. the kind of technological toys children could play with). These modifications are also suggested in the article by Bame et al. (1993) and are inherent in this kind of testing.

Bame and Dugger defined the PATT-USA factors as followed: (1) General interest in Technology, (2) Attitude Towards Technology, (3) Technology as an Activity for both Girls and Boys, (4) consequences of Technology, and (5) Technology is difficult. In their report only the high loading items for each factor are reported. In table 1 is given an overview of these factors, and two example items for each sub-factor and the number of items per factor.

Research questions

As stated in the introduction it can concluded that in the West-European, and more specific in the Flemish context, research in the field of technological literacy is rare but necessary. For the assessment of students' attitude towards technology an existing instrument, the PATT, is available although it needs a re-validation for the specific context and one can question whether it passes the test of time. More specifically it was argued that research is needed to re-validate the PATT in order to use it to measure attitudes of students at ISCED-level two. Another issue derived from the existing literature on the PATT, is the demand to reduce the number of items in the instrument without threatening the reliability of scores based on the PATT.

These issues have resulted in the following general research question for this study:

Can the PATT questionnaire in a more concise and still reliable version measure students' attitudes towards technology?

This general question can be divided into some more specific sub-questions:

Is there support for the assumed factor-structure in the PATT when administered at ISCED 2 level? If so, is a reduction of the number of items for certain or all factors possible? Does this reduction threaten the reliability scores? And contains this more concise PATT instrument sufficient construct validity?

Methodology

Kind et al (2007) postulate the following guidelines for formulating an attitude measure: A clear descriptions need to be put forward for the constructs that one wishes to measure. This description was withdrawn from the original PATT development in the dissertation of de Vries (1988). Because the original PATT questionnaire developed by de Vries (1988) was in Dutch, a good translation was also available to be used in Flanders.

A second description of Kind et al (2007) is that care needs to be taken when separate constructs are combined to form one scale, with justification that these constructs are closely related. In this research close attention is paid to this in the interpretation of the different items in the sub-factors.

Reliability of the measure needs to be demonstrated by confirming the internal consistency of the construct (e.g., by use of Cronbach's α) and by confirming unidimensionality (e.g., by using factor analysis). And validity needs to be demonstrated by the use of more than one method, including the use of psychometric techniques. All subscribed psychometric tests and techniques suggested by Kind et al. (2007) will be included in the different phases of our study as described below.

Design of the study

In order to answer these questions a study was set up that consisted of two steps. In a first step data gathered in a pilot study (n=251) are analysed. The main aim of this pilot study was to evaluate the factor-structure assumed by…in the PATT and to explore the possibility to reduce the number of items. In a second step, the reduced version of the PATT was used on a larger-scale survey (n=3039). This second step was aimed at validating this reduced PATT-instrument.

Statistical methods

The data of the pilot study were first analysed by means of an explorative factor analysis (EFA). Factor analysis is used because the data met both of the assumption from Cohen, Manion and Morrison (2007), namely the need of a sample size above 150 respondents and the minimum of five items for each factor. This method is typically used to explore previously unknown groupings of items and to seek underlying patterns clusters and factors (Cohen, et al. 2007). Although there was already a clear idea of the different sub-factors it was interesting to see how all 58 items corresponded. The factors composed by Bame et al (1993) contained only 42 of the 58 items, like showed above (table1). In the next step results are analysed with

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an EFA with oblique rotation because this makes it possible to undertake a data driven exploration taking into account the fact that latent variables might correlate and could contain some unexplained variance. A scree plot shows the 'elbow point' (Cattel, 1996).

Based on the outcome of this EFA and substantive arguments, factors were defined and tested on their reliability. In interpreting the factor analyses loadings of items between -.30 and .30 are not taken into account, as the items need to have a high enough correlation whit the factor they are part of. Cronbach's alpha (α) on each factor and the remaining impact of each item was taken into account to assure reliable factors with a reasonable number of items. To define a reliable factor Cronbach's alpha of .70 and higher are acceptable.

In the next step the remaining items from the pilot study were used in the main study on a larger group of students (n=3039). Allowing to confirm the first analysis this time the more stringent confirmative factor analysis (CFA), commonly used for testing a found set of factors against a hypothesised model (Cohen, Marion & Morrison, 2007), will be applied. Goodness of fit indices helped the researchers finding the most appropriate model. In the analysis the Comparative fit-index (CFI) and Root-Mean-Square-Error-of-Approximation (RMSEA) will was taken into account. For the CFI a score >.95 indicates a good model fit (Hu and Bentler, 1999) for RMSEA the maximum score is .05 for a good model fit between .05 and .08 is still acceptable (Hoyle, 1995).

Different models were compared with a Chi² test on the -2 Log Likelihood differences and Akaike's Information Criteria (AIC) to determine the best fitting model.

All analyses were done with the statistical program R of the Comprehensive R Archive Network (CRAN). Different packages like 'psych', 'car' and 'lavaan' were used to assure the quality of the software (Rosseel, 2012; Fox & Sanford, 2011; Revelle, 2011).

Sample

The pilot study conducted with 251 students (111 Girls, 137 Boys, 3 missing) from first grade of secondary education (12-14 years old) divided over first and second year in five different schools in Flanders (Belgium). Those schools had a rural or non-rural and public or non-public profile. All had to achieve the same national goals for technology but had different curricula. Every school however had at least two hours of technology a week.

In the main phase the more concise version of the PATT test was conducted in 17 schools with a total number of 3039 students. Students from the first and second years of secondary education where represented. Students had different curricula (e.g. Latin, economy, social sciences, electricity,…). This survey allowed the researchers to confirm previous findings from the pilot and framed a fitting model for this instrument.

Results

Pilot study

In our pilot study all 58 items from the original questionnaire were used. An Explorative Factor analysis (EFA) was applied. Both the scree test and the parallel analysis suggest a solution with five factors. Therefore an EFA solution with oblique rotation and a fixed number of five factors was retained as the best solution. The cumulative explained variance of the five factors was a satisfying 43% (table 2).

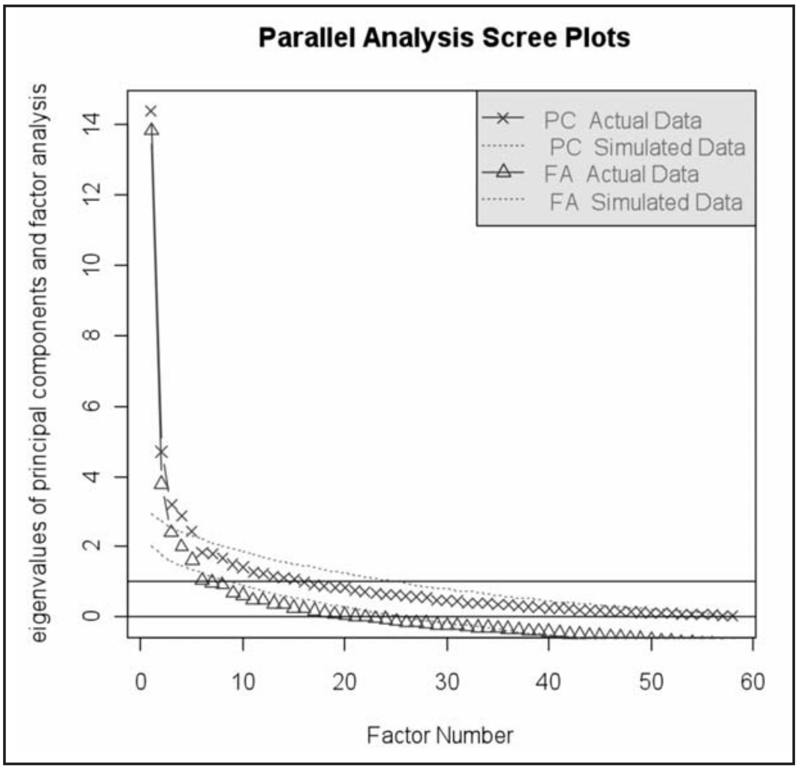

Figure 1. Screeplot Parallel factor analysis with all 58 items

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Eigenvalue	9.41	4.70	3.90	4.12	2.67
Proportion explained variance	0.16	0.08	0.07	0.07	0.05
Cumulative explained variance	0.16	0.24	0.31	0.38	0.43

Table 2. Eigenvalues, explained variance per factor and cumulative explained variance of the five factors after oblique rotation

Factor	Description	High score indicates	Items
1	General Interest	more interest	12, 16, 17, 18, 23, 27*, 28, 32*, 34, 39, 45, 46*, 50, 51*, 52, 57*,58*, 62*, 63, 69
2	Attitude towards technology	more positive attitude	22*, 28*, 29, 33, 40*, 46*, 51*, 57*, 58, 60, 64, 65*, 68*
3	Technology as an activity for both girls and boys	technology is for both genders	13, 19, 24, 30, 35, 41, 47, 53
4	Consequences of technology	more positive consequences	14, 20, 25, 27*, 31, 38*, 42*, 56*, 60*, 66*
5	Technology is difficult	technology is more difficult	26, 43, 44*, 49, 61*, 67*

*Table 3. Items with a loading >.30 in the different factors; * items newly added to the factor compared with the PATT-USA version*

It.nr	Question	factor loading	Decision
28	I will not consider a job in technology	.43 on F1 .34 on F2	Factor 1
32	I would rather not have technology lessons at school	.39 on F1 .46 on F2	Factor 1
46	I am not interested in technology.	.45 on F1 .36 on F2	Factor 1
51	Working in technology would be boring	.56 on F1 .35 on F2	Factor 1
57	Because technology causes pollution we should use less of it	.41 on F1 .53 on F2	Factor 2
58	I think machines are boring	.44 on F1 .48 on F2	Factor 2
60	Most jobs in technology are boring	.30 on F2 .39 on F4	Factor 4

Table 4. Items with a loading above .30 on more than 1 factor including the content based decision

Analysing the standardised factor loading for each result showed great resemblance with the factors as defined in the PATT-USA made by Bame and Dugger (1989).
Table 3 shows all the items for the different factors in our data. Items marked with an asterix (*) are items that in our analysis are components of these factors but not assigned to these factors in the PATT-USA survey. Taking a closer look items often appear in more than one factor, this might be a reason why they are not included in the analysis done by Bame and Dugger (1989).

As shown in table 4 seven items have a loading above 0.30 in more than one factor. Therefore the content of these items was analysed in order to identify the most appropriate factors. The decisions are summarised in table 4.

According to the number of items in the first factor 'General Interest' (20) and theoretical background of the test one can wonder whether this really is a unidimensional construct or whether it is a result of conducting an EFA on the total number of 58 items. To test this a new EFA was conducted with only the items of the factor 'interest'.

Results of the scree plot of the analysis (figure. 2) and the parallel test confirm the first analysis, leading to the conclusion that these 20 items measure general interest.

Although the scree plot showed a unidimensional factor, the content analyses indicated that there were two sub-

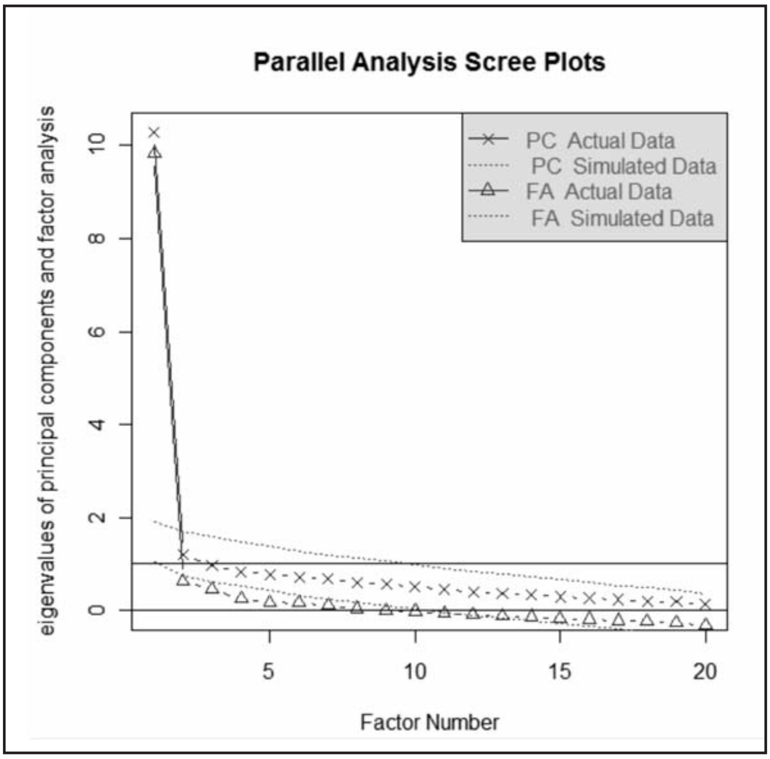

Figure 2. Scree plot Parallel factor analysis with 20 items from factor 1 'General interest'

Factor	Pilot Study Original factor		Reduced Factor	
	α	Number of items	α	Number of items
Technological career aspirations	.91	7	.92	4
Interest in technology	.87	9	.84	5
Attitude towards technology	.83	9	.81	4
Technology is for both, Boys and Girls	.80	8	.80	4
Consequences of technology	.67	10	.72	4
Technology is Difficult	.60	6	.64	4
Total number of items		51		25

Table 5. Summarising table with reliability coefficients before and after reducing the number of items in each factor

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factors, which will most likely are highly correlated. Thus a factor analysis with two factors and oblique rotation was conducted. From the results two clearly different factors were derived. Because of the clear distinction in content the first sub-factor of 'General Interest' was defined as 'Technological career aspirations' and the second as 'Interest in technology'. Examples of items of both factors are respectively: "I will probably choose a job in technology" and " There should be more education about technology". These factors seem to be related but one can assume that the correlation will not be perfect: a pupil can be interested in technology without considering a technological career. Therefore it seems theoretically appropriate to distinguish two separate factors.

For each of the six factors analysing the internal consistency was the first step, and if possible items were dropped either to increase reliability or to make an equal reliability factor with less items. Results for each factor are explained bellow in table 5.

Intermediate conclusions based on the pilot study

The original factor 'General interest' (Bame, et al, 1993) containing 18 items appeared to contain two underlying factors: career aspirations and interest in technology. They respectively consist of four and five items and have a reliability (α) above .80, considered to be good.

The factor 'Attitude towards technology' consisted of eight items in the original version, with a variety of questions about prosperity, environment, the need of mathematics etc. The reduced version with only four questions defines attitude as the extent to which someone finds technology boring or not. Given that all the items are formulated negatively, it could be more appropriate to change the title of the factor to 'Tediousness'.

The factor about technology as an activity for both boys and girls is reduced to only four questions out of the original eight items, without a loss in reliability (α=.80).

For the factor 'Consequences of technology' one of the four remaining items was not in the original factor. Nevertheless our analysis showed a bigger internal consistency of the items integrating this new item.

For the factor 'Technology is difficult' the results were not as straightforward as for the other factors. The original factor provided an answer on whether students thought technology was difficult based on five questions. In our analysis the factor consists of six items. Because of the low Cronbach's alpha (α=.60) the data were analysed again based on the content of the items and the theoretical frame made by Bame et al (1993). Items 15 and 21 were re-included. After adding these two extra items, four other items were dropped out and a reliability score (α) of .64 was still retained. This seemed to be the highest reliability possible. Although a reliability score (α) between .60 and .70 is questionable this factor is retained with four items in order to maintain a questionnaire including six different aspects of attitude towards technology. In the main study it is possible to re-evaluate this decision.
With a total number of 25 items divided over six factors this analysis of the first pilot study results in a questionnaire with six factors with sufficient reliability and less than half the number of items of the original PATT questionnaire. As such, this new concise version meets the need expressed in earlier research to reduce the PATT. In a next phase, the main study, this reduced version of the PATT is re-evaluated.

Further in the analysis and report all six factors will be referred to by just the essence of the factor whiteout specifically naming technology. This results in the factors: Career aspirations, Interest, Tediousness, Consequences, Gender, and Difficulty.

Main study

A confirmative factor analysis (CFA) is used to examine the dimensionality of the concise questionnaire from a different methodological approach and making use of another, larger sample of ISCED two pupils. The CFA was used to examine the model that resulted from the pilot study, containing six factors. If this theoretical model was not supported by the analysis, the modification indices were checked on possible improvements of the model.

Model	CFI	RMSEA	AIC	Chi²	df	P -2LL test
1	.928	.050	190904	2007	260	
2	.939	.046	190639	1740	259	<.001
3	.951	.043	184456	1402	236	

Table 6. The fit indices for the different models

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The model was also only accepted when the adaptation could be theoretically explained. This was repeated until a good fitting model was found that was in line with theoretical evidence as well.

In table 6 is the summary of the model fit indices for the three models that were estimated during the analyses are shown. Besides the fit indices (the comparative fit index (CFI), the Root Means Square Error of Approximation (RMSEA), Akaike's Information Criteria (AIC), Chi2 and the df) also the p-value associated with the Chi²-difference between nested models is reported. A p-value lower than 0.05 indicates that the newer model is considered to be a significantly better fitting model than the previous model. The description of these subsequent three models follows.

Model 1

The first model includes all factors as defined after the first pilot study. The factor structure is shown in figure 3. The fit indices for this model did not reach the critical values (CFI>.95; RMSEA<.50). Therefore the modification indices were inspected as inspiration for any improvements on the model. This resulted in the suggestion to add a factor loading of item 27 *'Technology lessons are important'* on the factor 'Interest'. In a second model this new factor loading was added.

Model 2

As shown in table 6, the second model, containing the cross loading of item 27, significantly improves the fit. The RMSEA has dropped under .05, considered to be good. Nevertheless the CFI is still lower than .95 indicating that the model still can be improved. Examining the modification indices suggests that a loading for item 24 ('A girl can become a car mechanic') should be added on the factor "Consequence'. However, one cannot consider this loading as theoretically relevant. Therefore the item was dropped out, given that its meaning seems equivocal. Moreover, explorative analysis shows that the internal consistency of the factor 'Gender' would increase from α=.74 to α=.82 without item 24. The third model tests whether this model without item 24 better fits to the data.

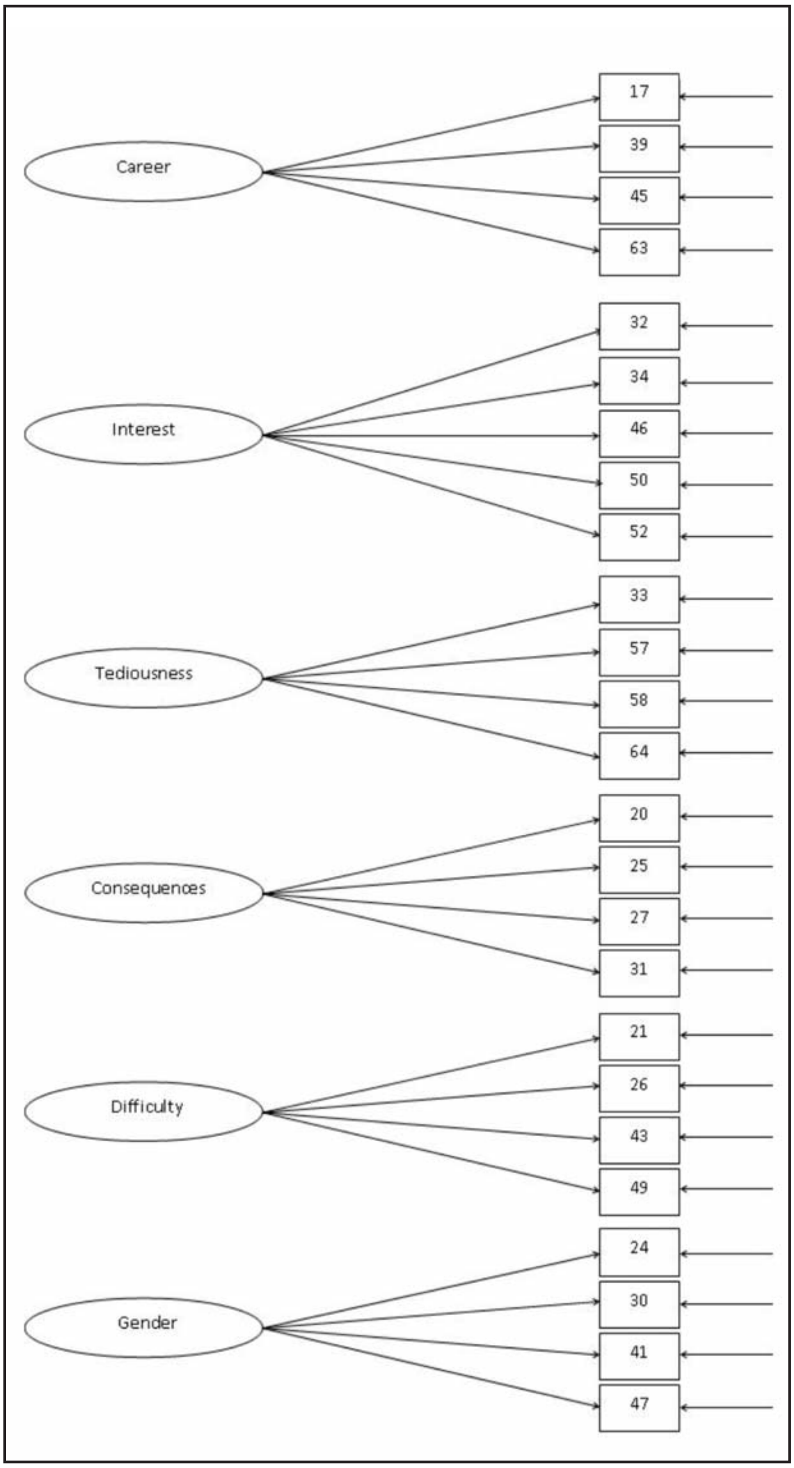

Figure 3. Model

	Career	Interest	Tedious.	Gender	Conseq.	Difficulty
Career	1.00	***	***	***	***	***
Interest	0.68	1.00	***	***	***	***
Tediousness	0.51	0.59	1.00	***	***	***
Gender	-0.08	-0.04	0.09	1.00	*	***
Consequences	0.37	0.52	0.36	0.009	1.00	***
Difficulty	0.18	0.14	0.009	0.009	0.24	1.00

*Table 7. Correlation matrix and significance. ***= p<0.001; **p = <0.01; * = p<0.05*

Model 3
Goodness of fit indices shows an acceptable CFI and RMSEA for this third model. Moreover, the Akaike's Information Criteria was a lot lower than for model 2. Concluding that this third model shows a better fit than the second model, it is considered as our final model.

Table 7 summarises the correlations between the factors, based on this final model. According to Cohen's rule of thumb Career, Interest and Tediousness are strongly correlated. Also Consequences is strongly correlated with Interest and this same factor has a medium correlation with Career and Tediousness and a light correlation with difficulty. Difficulty also is lightly correlating with Career and Interest. Only Gender has no correlations with the other factors. All correlations are significant. Although some correlations are strong, none of them are absolute. The six different sub-factors are all differ at least a little from each other.

Conclusion and discussion

Our research consisting of a pilot study (n=250) and a main study (n=3000) was able to give an answer to the question about the usefulness of the PATT questionnaire in a more concise and still reliable version to measure students' attitudes towards technology.

Doing factor analysis on the collected data evidence was found for the assumed factor-structure in the PATT when administered at ISCED 2 level. Hereby the assumption of Osborne et al (2003) that a factor for attitude towards a subject actually consists of a number of sub-factors can be supported. And the best that can be done is to ensure that the sub-factors, which form the concept of attitude, are valid and reliable measures of the constructs they purport to measure and to look for the significance of each of these aspects. Six of these so-called sub-factors in the PATT questionnaire were found. All of these six sub-factors are highly in accordance with the original factors made by Bame and Dugger (1989), although all of them contain a reduced number of items. Five of the factors have at least an acceptable internal consistency (>.70) and only one of the factors, 'Difficulty' has a dubious internal consistency. The attitude of whether technology is for boys and girls, or boys is the only sub-factor that shows no correlation with the other sub-factors. All other factors are at least lightly correlated with three other sub-factors. This may not be surprising as the factors are all measuring different aspects of attitude towards technology.

Although the research has been done in the Flemish context results are likely to be similar in other western countries. This is mainly because Flanders shares both a history and a future in technology education that faces broadly the same challenges in this domain.

The reduction of the number of items for all factors whiteout threatening the reliability scores was also successful and this more concise PATT instrument has sufficient construct validity. Table 8 describes the short questionnaire (PATT-SQ). The contained items were linked to the relevant factors. This PATT-SQ is useful as an instrument for measuring different aspects of attitude towards technology in secondary schools in Flanders. The instrument is as short as possible and shows sufficient reliability. It is easy to use and analyse and does not need a lot of time to be administered.

Teachers and students will benefit from this instrument as they now can clear out how these attitudes can be influenced and what attitudes play a distinct role in further academic of technological careers. A broader international study about students' attitudes of technology would be an interesting follow up as this was first conducted 25 years ago (Raat, de Klerk Wolters & de Vries, 1987).

These and following options become possible after the successful re-validation of the PATT instrument. Little is known about student and teacher variables that play a significant role in the development of attitudes towards technology as an outcome variable nor about the evolution over time. On the other hand, these six attitude factors can now been measured as an intermediate or control variable for other student outcomes like technological literacy. When used with other instruments it is highly useful that the PATT-SQ is a concise and still reliable instrument.

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Factor	Items – *to be measured on a 5 point Likert-scale*
Technological career aspirations	17. I will probably choose a job in technology 39. I would enjoy a job in technology 45. I would like a career in technology later on 63. Working in technology would be interesting
Interest in technology	27. Technology lessons are important 32. I would rather not have technology lessons at school 34. If there was a school club about technology I would certainly join it 46. I am not interested in technology 50. There should be more education about technology 52. I enjoy repairing things at home
Tediousness towards technology	33. I do not understand why anyone would want a job in technology 57. Most jobs in technology are boring 58. I think machines are boring 64. A technological hobby is boring
Technology is for both, Boys and Girls	30. Boys are able to do practical things better than girls 41. Boys know more about technology than girls do this 47. Boys are more capable of doing technological jobs than girls
Consequences of technology	20. Technology makes everything work better 25. Technology is very important in life 27. Technology lessons are important 31. Everyone needs technology
Technology is Difficult	21. You have to be smart to study technology 26. Technology is only for smart people 43. To study technology you have to be talented 49. You can study technology only when you are good at both mathematics and science

Table 8. Final list of items for each factor, item numbers from PATT-USA questionnaire

RESEARCH

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