Investigating the Factor Structure of Pupils Attitudes towards Technology




Jason Power
University of Limerick
email: jason.power@ul.ie

Jeffrey Buckley
University of Limerick
email: jeffrey.buckley@ul.ie

Dr Niall Seery
University of Limerick
email: niall.seery@ul.ie

Dr Donal Canty
University of Limerick
email: donal.canty@ul.ie

Abstract

As STEM education becomes the focus of educational reforms in knowledge based economies, technological literacy is seen as a key outcome of many STEM related programmes. When considering technological literacy it is vital that educators are cognisant of the attitudinal dimension. This is especially true when developing a programme of Initial Technology Teacher Education (ITTE) as efforts aimed at developing technological literacy of future teachers have the potential to achieve exponential impacts throughout the career of technology educators.

Students of technology teacher education are in a period of attitudinal malleability due to the paradigm shift from being a pupil to an educator. Coupled with their attitudinal disposition being of paramount importance within their oncoming professions, there is a pedagogical need to monitor their perceptions of technology education throughout their degree programme. This paper presents the initial phase in an envisioned longitudinal study to design a comprehensive tool with the capacity to elicit such perceptions across the broad spectrum of factors which constitute to technology education, with the focus of this particular phase being on attitudes towards technology.

The Pupil's Attitudes Toward Technology (PATT) tool was adapted for use in an ITTE degree programme. The instrument was administered to a cohort (N=124) of student teachers in the first and last week of their first semester within the programme. Within this semester, students complete modules relating to educational theory, design, graphical communication, and manufacturing technology.

The results of this study identify a five factor model as the model of best fit. Further interpretation of the factors within this model suggests similar factors to those which emerged from previous studies. This study has generated significant insight into ITTE students' attitudes towards technology, however due to its pilot nature further work is needed to draw definitive results.

Introduction

In recent years there has been a considerable emphasis placed upon the inclusion of increased levels technology within the classroom as a proposed solution to what many feel are pedagogical deficiencies (Buabeng-Andoh, 2012). This agenda is born from the societal need for increased technological proficiency to facilitate students ineluctable introduction to operating in a conceptual age (Pink, 2005). Therefore, the ongoing drive for higher levels of technology within classrooms is considered axiom. Instead, the focus of this paper will be on associated attitudes towards technology.

Albarracin, Zanna, Johnson and Kumkala (2005) posit that attitudes are malleable. From a pedagogical position this is of significant interest as research has shown that students who demonstrate a positive attitudinal disposition towards a particular area of study also demonstrate higher interest levels and performance within that area (Krathwohl, Bloom, & Bertram, 1964). This suggests that student teachers who demonstrate a positive attitudinal disposition towards technology will be more likely to achieve the required levels of technological literacy (Bame, Dugger Jr, de Vries, & McBee, 1993).

This is especially important in the context of future technology teachers. Technology educators are conceptualised as the epicentre of a ripple effect where an effective educator has the potential to influence the technological literacy of thousands of students across their career. Considering the magnitude of effect that teachers can have on pupils (Hattie, 2008), pertinent attitudes of teachers are therefore of paramount importance. The amalgam of the criticality of technological literacy, in conjunction with the potential impact of teachers, merits the adoption of an attitudinal lens when examining pedagogical practices within Initial Technology Teacher Education (ITTE).

Attitudes towards Technology in Initial Technology Teacher Education

Investigations into attitudes towards technology were instigated by de Vries (1988) through the development of the Pupils Attitudes Toward Technology (PATT) tool. This tool contains multiple items designed to gain insight into pupils' attitudes relative to a variety of aspects associated with technology such as gender and societal roles, education and employment perspectives, and general interest. This has subsequently been re-developed for use within the USA (Bame et al., 1993) suggesting the efficacy of the original tool as a valid methodological foundation requiring surface level re-contextualisation for different environments.

Students within an ITTE programme are constantly subjected to information pertinent to technological advances and regularly engage with active and experiential learning methodologies where relevant technology is ubiquitous. Learning outcomes are regularly associated with developing technological competencies such as technological capability and technological literacy. As such attitudes towards technology should refine and develop continuously throughout their degree programme. This is in turn based on the supposition that the learning outcomes related to enhanced technological literacy and technological understanding are achieved.

Research Focus

Due to the nature of the environment embodied within ITTE where pedagogical practices both drive and respond to technological evolutions, this creates the need for a tool with the capacity to validly and reliably elicit attitudes towards technology in this dynamic context. It is posited that such a tool would require regular adaptations over time in response to the constantly changing setting. Therefore, the first phase in the development of such a tool is to elicit the broad factors associated with attitudes towards technology in this context. The development of this tool would then facilitate the investigation of the pertinent attitudes of students during their engagement with ITTE modules.

Method

The purpose of this research agenda is to elicit the factor structure of the PATT tool as a foundation for the development of a new tool capable of validly and reliably interpreting student teachers attitudes towards technology education. Specifically, this study sought to gain insight into the factor structure of ITTE students' attitudes towards technology to support further investigation into additional constructs meriting inclusion the aforementioned tool.

Research has previously been conducted with the intent of eliciting the factor structure of the PATT tool (Ardies, de Maeyer, & Gijbels, 2009; Bame & Dugger Jr, 1989). This research guided the methodological design of this study however due to the different context minor changes were made to the approach. It was decided that the original version of the PATT tool (de Vries, 1988) would be adapted to align with this new context based on the large number and non-domain specific nature of the items. In order to update the scale, and adapt to the domain of operation, various adaptations were made to the original PATT tool. A ten-point Likert scale was also utilised due to the anticipated small sample size as the additional variance has been found to be more reliable with smaller cohorts (Wittink & Bayer, 1994). The use of a ten-point scale has also been shown to be comparable with five and seven point scale for analytical tools such as confirmatory factor analysis (CFA) which is a core aspect of the method employed in this study (Dawes, 2008). However, it is intended to revert to the original five point scale subsequent to this pilot phase.

A test/re-test approach using the adapted 89 item scale was utilised. New entrants into an ITTE programme completed the pre-test before engaging in any technology related module. After the conclusion of their first semester participants again completed the same 89 item version of the scale. Upon completion of the study samples were considered valid if a complete pre and post data set was available. This resulted in 113 valid data sets. A series of statistical analyses were subsequently conducted to determine the underlying factor structure of the tool.

Statistical Analysis

A series of both exploratory factor analyses (EFA) and confirmatory factor analyses (CFA) were conducted to elicit the underlying factor structure of the PATT tool. Cohen, Manion and Morrison (2007) identify a need for 150 respondents and a minimum of 5 theoretical items loading on each factor for the purposes of this analysis. The number of respondents in this study (n=113) did not meet this criteria however as this was an exploratory study designed with the intent of gaining insight to inform the progression of the envisioned longitudinal study this was deemed acceptable.

Initially an EFA was run on the results from the pre and post-tests with oblique promax rotation and no limitation on the number of factors to retain. The scree plots for both suggest an underlying 5 factor model and are illustrated in Figure 1. The eigenvalues, explained variance and cumulative explained variance of these five factors for the pre and post-test samples are illustrated in Tables 1 and 2 respectively.

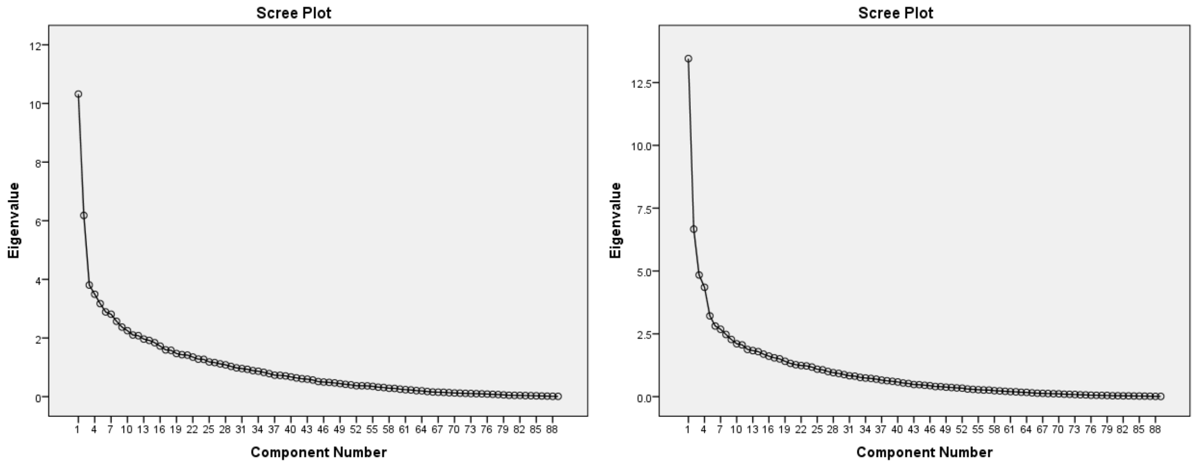

Figure 1: Scree plots for exploratory factor analyses on the pre (left) and post (right) responses to the PATT survey

Table 1: Eigenvalues, explained variance and cumulative explained variance of the five factors for the pre-test sample

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Eigenvalue	10.322	6.181	3.806	3.493	3.173
Proportion of explained variance	11.598	6.945	4.276	3.925	3.565
Cumulative explained variance	11.598	18.544	22.820	26.745	30.310

Table 2: Eigenvalues, explained variance and cumulative explained variance of the five factors for the post-test sample

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Eigenvalue	13.453	6.666	4.841	4.354	3.215
Proportion of explained variance	15.116	7.490	5.439	4.892	3.612
Cumulative explained variance	15.116	22.605	28.044	32.936	36.548

The next stage of the analysis was to develop a factor model with sufficiently high internal reliability within each factor. While the EFA results suggested a 5 factor model, previous study conducted by Ardies et al. (2009) and Bame and Dugger Jr (1989) suggest a 6 factor model. Based on these results, a second round of EFA were conducted on both data sets however this time both a 5 and 6 factor model was specified to be retained. An oblique promax rotation was specified for these analyses. The resulting Cronbach's Alpha values are illustrated in Table 3 below.

Table 3: Cronbach's Alpha values for each factor in the 5 and 6 factor solutions for the pre and post-test samples

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
Pre Test 5 Factors	0.887	0.798	0.803	0.333	0.511	
Post Test 5 Factors	0.909	0.861	0.675	0.733	0.660	
Pre Test 6 Factors	0.879	0.646	0.775	0.286	0.388	0.382
Post Test 6 Factors	0.901	0.86	0.701	0.733	0.561	0.651

An observation of the Cronbach's Alpha values illustrated in Table 3 identifies higher internal reliability within factors which emerged from the post-test dataset. Due to the participants' engagement with ITTE modules between administrations of the PATT tool it is posited that their conceptions of technology evolved during this time which resulted in the intrinsic clarification in their associated attitudes. Stemming from this conjecture the post-test dataset was utilised within the subsequent confirmatory factor analysis.

A number of factor models were run through a confirmatory factor analysis. Both the 5 and 6 factor structures that were revealed through the earlier exploratory factor analyses were initially tested. These were examined both with and without latent variables correlating. The results showed that a 5 factor model with correlating latent variables was the best fit. A number of iterations were subsequently examined with alternations made based on resulting Cronbach's Alpha values for each factor based on the removal of test items. Fit indices of each examined model are presented in Table 4.

Table 4: Fit indices of CFA models

	χ^2	DF	RMSEA	CFI	AIC
5 Factors: Latent variables uncorrelated	3072.159	1652	0.088	0.56	3426.159
5 Factors: Latent variables correlated	3004.66	1642	0.086	0.578	3378.66
6 Factors: Latent variables uncorrelated	3385.329	1829	0.087	0.543	3757.329
6 Factors: Latent variables correlated	Undefinable due to sample size limitations or very poor model fit				
Below based on 5 Factors with latent variables correlated					
Q21 Loading on F5	2984.795	1641	0.086	0.584	3360.795
Q21 Loading on F5 and Q9 Loading on F1 and F2	3118.332	1699	0.086	0.57	3500.332
Removed Q24, Q60 and Q61	2764.293	1710	0.085	0.597	3128.293
Removed Q9, Q24, Q60 and Q61	2652.575	1474	0.084	0.606	3008.575

The fit indices shown in Table 4 illustrate that no model meets the critical values required (CFI>.95; RMSEA<.05). The final model inspected, the 5 factor model with latent variables correlated and items Q9, Q24, Q60 and Q61 removed was the closed to reaching these values. The Cronbach's Alpha values for the factors in this model are illustrated in Table 5 and CFA model is illustrated in Figure 2.

Table 5: Cronbach's Alpha values for final model

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Cronbach's Alpha	0.909	0.861	0.787	0.708	0.732

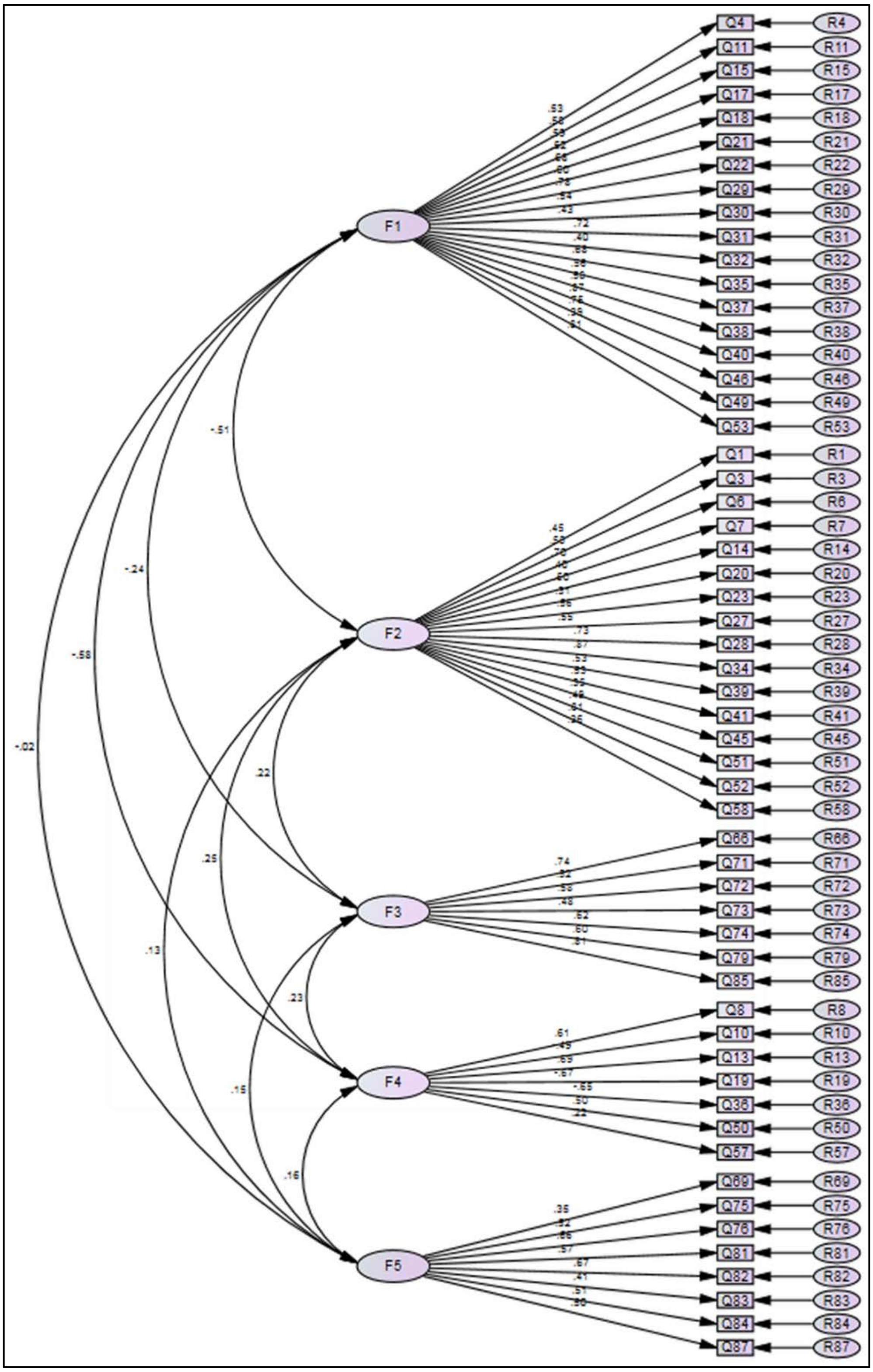

Figure 2: CFA model of best fit

Factor Interpretation

Upon ascertaining the model of best fit, the final stage of the analysis involved interpreting the factors based on the included items. While typically this would be an intrinsic element to the quantitative modelling, it was decided at this stage to separate the factor interpretation from the CFA modelling as the intent of this study was not to generate a final model as this analysis will be repeated when additional data is gathered. An observation of the items loading on each yields tentative factors identified in Table 6. As factor interpretation is based on researcher inference, a selection of sample items loading on each factor is included. As previously mentioned the CFA model is considered tentative. In order to allow for further refinement in the next round of testing a comparatively large number of items were retained. Given the pilot nature of the current study the factor labels in Table 6 are considered by the authors to be suggestive of future refinement directions as opposed to complete. Cognisant of the non-finalised version of the factor structure; comparatively low face validity when compared to more refined versions (Ardies et al. 2009) is acknowledged. This reduction in face validity is accepted in order to allow for greater levels of plasticity in future versions primarily informed by the EFA outlined previously.

Table 6: Factor descriptions and sample items

Factor	Description	Example Items
1	Technology in education and the economy	I believe there is too much of a focus on technology education in schools. I believe technology should be covered less at second level. I do not understand why anyone would want a job in technology. The world would be a better place without technology. Using technology makes a country less prosperous. Working in technology would be boring.
2	Interest towards technology	When something new is discovered, I want to know more about it immediately. If I was to change career could see myself working in a technology related job. If there was a technology club/society I would certainly join it. There should be more education about technology. Working in technology would be interesting.
3	Affordances of technology	In technology you can think up new things. Technology has a large influence on people. I think technology is often used in science. In everyday life, I have a lot to do with technology.
4	Technology and Gender	A female can perform well in a technology subject. A female can become a car mechanic. Males are more suited to practical subjects than females. Males are more capable of performing technological jobs than females. Everybody can study technology.
5	Limited conceptions of technology	In technology there is little opportunity to think up things yourself. When I think of technology I mainly think of computer programs. Only technicians are in charge of technology. Technology has always to do with mass production. In technology there are less opportunities to do things with your hands.

Discussion

The pilot stage of the redevelopment of the PATT instrument towards a more focused derivative suggests that the more concise version of the instrument will also yield a more reliable format. In addition, the updates to media references and the increased relevance of the more focused version do not appear to have negatively impacted the reliability of the instrument. It is important to note that the results highlighted as sub optimal in the previous section have been linked to the relatively small sample size. At this pilot stage of the redevelopment these limitations are considered acceptable but they highlight the need for future larger scale applications.

The factor analysis used supports the views of Osborne, Simon and Collins (2003) who posited that attitudes towards a particular subject consist of multiple sub factors. This is further supported by the findings of Ardies et al. (2009) who conducted a similar redevelopment with a greater sample size. In contrast to Ardies et al. (2009) the model of best fit in this study was found to consist of five factors as opposed to six. The internal consistency of the five factors ranged from .732 to .909. Interestingly although Ardies et al. (2009, p.17) utilised a six factor model one of the identified factors was found to have "dubious" internal consistency.

The factors emerging for this study are similar to those retained in the studies conducted by Ardies et al. (2009) and Bame and Dugger Jr (1989). All studies identify factors pertinent to gender equity in technology, interest in technology and consequences of technology. Minor deviations are seen in factors associated with attitudes towards technology and the difficulty of technology but this likely stems from researcher inference in naming the factors. The emergence of similar factors across these studies suggests a high degree of validity in its underlying structure. As such, these factors merit recognition in the progression of this research avenue towards the creation of a tool designed to elicit attitudes towards technology education.

Conclusion

Given the often difficult nature of assessment that focuses on affective learning outcomes, the PATT tool provides a useful indicator of attitudinal change pertinent to technology. As discussed at the beginning of this paper there is an international drive to increase the use of technology in all classrooms. This highlights the need for teacher educators to be aware of the impact of attitudinally targeted learning outcomes.

With the longitudinal agenda of creating a tool with the capacity to validly gather attitudinal perspectives towards the entire spectrum of technology education, this study has offered a significant perspective in the specific area of attitudes towards technology. With the wide array of factors within technology education, the design of such an instrument warrants a clear factor structure with strategically selected appropriate items. The results of this study coupled with other similar studies identify a number of clear factors and items within this context for this purpose. Concurrently, from the perspective of a practitioner, the development of this tool would offer a more accessible way of determining their students pertinent attitudes thus facilitating the attainment and assessment of attitudinally targeted learning outcomes.

Reference List

Albarracin, D., Zanna, M., Johnson, B., & Kumkala, G. (2005). Attitudes: Introduction and Scope. In D. Albarracin, B. Johnson, & M. Zanna (Eds.), *The Handbook of Attitudes* (pp. 3–19). New Jersey: Lawrence Erlbaum Associates, Inc., Publishers.

Ardies, J., de Maeyer, S., & Gijbels, D. (2009). Reconstructing the Pupils Attitude Towards Technology-survey. *Design and Technology Education: An International Journal*, *18*(1), 8–19.

Bame, E., & Dugger Jr, W. (1989). *Pupils' Attitude Toward Technology - PATT-USA Report Findings*.

Bame, E., Dugger Jr, W., de Vries, M., & McBee, J. (1993). Pupils' Attitude Toward Technology - PATT-USA. *Journal of Technology Studies*, *19*(1), 40–48.

Buabeng-Andoh, C. (2012). Factors Influencing Teachers' Adoption and Integration of Information and Communication Technology into Teaching: A Review of the Literature. *International Journal of Education & Development Using Information & Communication Technology*, *8*(1), 136–155.

Cohen, L., Manion, L., & Morrison, K. (2007). *Research Methods in Education* (6th ed.). Oxfordshire, England: Routledge.

Dawes, J. (2008). Do Data Characteristics Change According to the Number of Scale Points Used? An Experiment Using 5-Point, 7-Point and 10-Point Scales. *International Journal of Market Research*, *50*(1), 61–77.

de Vries, M. (1988). *Techniek in het Natuurkunde-Onderwijs*. Technische Universiteit Eindhoven.

Hattie, J. (2008). *Visible Learning: A Synthesis of Over 800 Meta-Analyses Relating to*

Achievement. London: Routledge.
Krathwohl, D., Bloom, B., & Bertram, B. (1964). *Taxonomy of Educational Objectives: Handbook II. Affective Domain*. New York: David McKay Company Inc.
Osborne, J., Simon, S., & Collins, S. (2003). Attitudes Towards Science: A Review of the Literature and its Implications. *International Journal of Science Education*, *25*(9), 1049–1079.
Pink, D. (2005). *A Whole New Mind: Why Right-Brainers Will Rule the Future*. New York: Penguine Group (USA) Inc.
Wittink, D., & Bayer, L. (1994). The Measurement Imperative: Empirical Results on the Number of Scale Points Give Managers a Reliable Gauge for Assessing Customer Satisfaction. *Marketing Research6*, *4*(9), 14–22.