



Explaining secondary school students' attitudes towards chemistry in Chile

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L. H. Montes, ^a R. A. Ferreira *^a and C. Rodríguez ^{ab}

Research into attitudes towards chemistry in Latin America and indeed towards science in general is very limited. The present study aimed to adapt and validate a shortened version of Bauer's Attitude toward the Subject of Chemistry Inventory version 2 (ASCIV2) for use in a Latin American context. It also explored attitudes towards chemistry of Chilean secondary school students, and assessed the effect of school type, year group, gender, and chemistry achievement on both cognitive and affective dimensions. The participants were 523 secondary school students from public, private subsidised, and private schools in Chile. Exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) were first carried out to validate ASCIV2. The results of CFA showed that ASCIV2 retained the two-factor structure and showed optimal model fit, but three items had to be removed from the original instrument. The research also showed that attitudes towards science were neither positive nor negative, a reality similar to that of other countries. The results of multivariate and univariate analyses of variance showed significant effects of year group and chemistry achievement on attitudes towards chemistry. No effects of school type, gender or interactions between factors were found. Follow-up analyses revealed that as students advance through school their attitudes decline, but that the higher their chemistry marks, the more positive their attitudes become. These findings are partially in line with previous data from other countries and are a starting point for more research into attitudes towards chemistry in Latin America.

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Introduction

The natural sciences are present throughout the educational process of all students, who seem to show particular curiosity and motivation for these disciplines during their early years of schooling. However, these favourable attitudes that arise at an early age do not remain constant throughout a student's time at school. They in fact tend to decrease, and in the case of chemistry in particular, there is a gradual loss of interest in the subject, accompanied by feelings of boredom and rejection, and experiences of failure (Murphy and Beggs, 2003; Vázquez and Manassero, 2008; Potvin and Hasni, 2014). Indeed, the learning of chemistry is becoming less attractive for children and young students, which has a direct influence on the understanding of key concepts associated with the discipline, and consequently on school achievement (Coll and Treagust, 2003; Taber and García-Franco, 2010; McClary and Bretz, 2012). Attitudes towards science in general have been widely investigated in the United States (Pell and Jarvis, 2001; George, 2006; Ferreira and Trudel, 2012; Lu *et al.*, 2016), Canada (Park *et al.*, 2009; Potvin and Hasni, 2014) and Europe (Barmby *et al.*, 2008; Krapp and Prenzel, 2011;

Sjaastad, 2013). However, research in other parts of the world is substantially less abundant. This is the case in Latin America, where very little research on attitudes towards science has been produced to date. To the best of our knowledge, only a few studies, conducted in Colombia, have looked at attitudes towards chemistry among university students (Molina *et al.*, 2011; Reyes *et al.*, 2014; López Guerrero *et al.*, 2017). Regarding secondary school students, there is an almost complete absence of research on attitudes towards science or chemistry in particular.

School teachers often state that attitudes play an important role in achieving goals, and that failure in a subject can provoke negative feelings such as apathy and disinterest (Macías, 2010; Kanafiah and Jumadi, 2013). They are not alone in recognising this threat; research has also identified attitudes as a factor that can strongly influence school performance and the choice of university degree (Brown *et al.*, 2014). In fact, there is evidence that students with intentions to pursue a scientific career have a positive attitude towards disciplines such as chemistry (Lyons and Quinn 2010). At the same time, attitudes towards chemistry have been found to predict academic performance in the subject (Brandriet *et al.*, 2011).

While school achievement and attitudes towards science seem to affect each other positively, other factors can have a negative effect on attitudes. For instance, attitudes towards science tend to become less favourable with age, which seems

^a Facultad de Educación, Universidad Católica de la Santísima Concepción, Concepción, Chile. E-mail: roberto.ferreira.c@gmail.com

^b Facultad de Psicología, Universidad de la Laguna, La Laguna, Spain

to be related to the content of the science curriculum. While the primary school curriculum focuses on materials such as natural phenomena or the human body, the secondary school content is more abstract and includes concepts that are not observable to the naked eye, and therefore require the use of higher thinking skills (George, 2006; Said *et al.*, 2016). These findings, however, need to be interpreted with caution, as age or year group may interact with other factors. This was the case in a study conducted by Cheung (2009), who investigated the interaction effect between year group and gender in explaining attitudes towards chemistry. He found that male students enjoyed chemistry theory lessons more than their female counterparts during the first two years of secondary school. However, as they progressed into the final two years, their liking for chemistry laboratory work declined, matching that of their female counterparts. In contrast, female students' enjoyment of chemistry grew steadily across year groups, before sinking again around the final year. Another important factor that can influence beliefs and feelings towards the chemical sciences is the sociocultural context in which students are immersed, for instance, the neighbourhood in which they live, including friends and family relations (Anwar and Bhutta, 2014).

Hence, attitudes seem to be modulated by a number of factors that constitute a more complex construct than expected, and this reveals the need to address them across different educational levels and cultural contexts. In Latin America, and particularly in Chile, there are virtually no studies that have addressed attitudes towards chemistry – or even science in general – and the relation of these attitudes to the above factors. Thus, the main aims of the present work are to validate a scale (ASCIv2) and to assess a number of factors that may affect attitudes towards chemistry of Chilean secondary school students, including gender, school type, year group, and chemistry achievement.

Measuring cognitive and affective components of attitudes towards chemistry

The concept of attitude has been widely debated over the years (*e.g.*, Ajzen, 2001; Osborne *et al.*, 2003; Reid, 2006; Barmby *et al.*, 2008). One of the conclusions that have been drawn is that attitude represents a multidimensional construct comprising primarily cognitive, affective, and behavioural aspects. A more restrictive view of attitudes suggests that they are a set of feelings that a person has about an object, based on beliefs about that object (Kind *et al.*, 2007). This implies that attitudes are reduced only to cognitive and emotional dimensions, because these attitudinal dimensions can simultaneously explain behavioural predispositions (Barmby *et al.*, 2008). Xu and Lewis (2011) also advocate the two-dimensional framework of attitude since students usually state that science is challenging and interesting, which represents the cognitive and affective domains, respectively. Thus, both components are conceptually distinct, and it is therefore important to know the students' answers to questions that point to these two dimensions separately.

Over the years, a number of instruments to measure attitudes towards chemistry have been developed and validated, including the Cognitive Expectations for Learning Chemistry Survey (CHEMX) (Grove and Bretz, 2007), Colorado Learning Attitudes about Science Survey (CLASS) (Adams *et al.*, 2008), Chemistry Self-Concept Inventory (CSI) (Bauer, 2005), and Attitude towards the Subject of Chemistry Inventory (ASCI) (Bauer, 2008). More recently, Xu and Lewis (2011) devised a new shorter version of ASCI (ASCIv2), which measures intellectual accessibility and emotional satisfaction. This instrument satisfied internal consistency and test-retest reliability, and was further supported by confirmatory factor analysis (CFA). As the authors claim, the two-factor scale represents measures of cognitive and affective components of attitude. The same instrument has been used with other samples at different universities within the United States and abroad, with the aim of obtaining further reliability and validity. For instance, Brandriet *et al.* (2011) used ASCIv2 to diagnose changes in attitude in first-year chemistry students at two universities in the United States. They found that ASCIv2 showed good internal consistency reliability as measured by Cronbach's alpha, and relatively good validity obtained using CFA. Xu *et al.* (2012) and Vishnumolakala *et al.* (2017) used ASCIv2 to measure students' attitudes towards chemistry, as well as other constructs, among first year undergraduate students in Australia. In these two studies, ASCIv2 showed relatively good or good internal consistency and validity. However, when used outside English-speaking countries, ASCIv2 has not shown the same consistency and validity. For instance, in a study conducted at three universities in Saudi Arabia (Xu *et al.*, 2015), ASCIv2 showed relatively poor internal consistency and validity for the two-factor and 8-item scale. Only after dropping item 6 (chemistry is challenging–unchallenging) did fit indices improve to an acceptable level. Another study that used ASCIv2 was that of Kahveci (2015) on high school students in Turkey. She used exploratory factor analysis (EFA) to adapt and validate the scale, and reported strong internal consistency with Cronbach's alpha values of 0.86 and 0.79 for “intellectual accessibility” and “emotional satisfaction”, respectively. In addition, use of the two-factor structure explained 56% of the variance, which suggests the applicability of using this scale in other populations of secondary school students. One difference to the original structure of ASCIv2 was that one item (chaotic–organized) loaded strongly on “intellectual accessibility” instead of “emotional satisfaction”, as in the original instrument. Since Kahveci only reported EFA indices, it is difficult to evaluate whether the structure obtained under this analysis can be confirmed using CFA, which would be critical for validation. The above results suggest that ASCIv2 is appropriate for use in different contextual settings, but caution must be taken regarding the way in which individuals respond to each of the items, and whether items will load on the same factors. It should therefore be noted that ASCIv2 seems adequate for measuring cognitive and affective attitudes towards chemistry in Anglo-Saxon contexts, but when used elsewhere, some adaptation to the structure may be necessary.