Causal judgments of positive mood in relation to self-regulation: A case study with Flemish students

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Abstract

To examine students' causal judgements of positive mood in relation to self-regulation, 128 participants from two different schools representing two distinct educational environments (Technical/Vocational School (TSO/BSO): *N* = 63; General Secondary School (ASO): *N* = 65) were asked to judge 45 statements containing three possible relationships (A → B; A← B; A <> B) for all iterations of 5 constructs associated with *positive mood*, namely *Hope, Optimism, Resilience, Confidence, Persistence*, 4 constructs associated with self-regulation, namely *Motivation, Social support, Problem-solving Learning goals*, and 1 construct representing *Academic performance*. Based on a Pareto analysis, mental models were constructed for each school. An analysis of the mental models indicates that all students believe positive mood constructs to be causally related to self-regulation constructs with *Academic performance* identified as the main driver and *Learning goals* as the primary outcome for both schools. It is concluded that an appreciation of participants' causal attributions of positive mood states in relation to self-regulation can present a clearer picture of the conditions under which participants' causal understanding of positive mood and self-regulation constructs can be activated and used as an interpretive and evaluative framework in learning encounters.

Keywords: Self-regulation; Positive mood; Optimism; Hope; Pareto analysis; Interactive Qualitative Analysis; Nonlinear dynamics; Complex systems

1. Introduction

In a review of three decades' research on the topic of self-regulation, Boekaerts, Maes, and Karoly (2005, p. 150) defines self-regulation (SR) as a *multi-component, multi-level, interactive, self-steering process that targets one's own cognitions, affects and actions, as well as features of the environment for modulation in the service of one's own goals*. In this definition, Boekaerts et al. (2005) not only acknowledges the construct of SR as a complex, interactive process but she also draws attention to the role of emotions and the environment in self-regulation.

Attempts to integrate emotional–motivational aspects with SR have been made by focusing on the role of coping in SR (Boekaerts & Corno, 2005), *volition* (Corno, 1993), and *emotion* (Barrett, Gross, Christensen, & Benvenuto, 2001; Schutz & Davis, 2000). Recently, Eftklides and Volet (2005) have argued for the importance of understanding how emotions can inhibit and facilitate learning, as well as understanding the conditions under which emotions can have long term facilitative effects on learning, while Zeidner, Boekaerts, and Pintrich (2005) argue that a better understanding of the impact of positive moods on students self-regulatory performance is sorely needed. Attention has recently also been drawn to the necessity of examining students' mental models of self-regulated learning (SRL) and understanding how mental models contribute to effective self-regulation in learning (Winne, 2005a).

In this paper, we draw on ideas in the area of dynamic systems theory (Capra, 2005; Carver & Scheier, 2005a, 2005b; Lorenz, 1993) and cognition (Anderson, 1990) to describe self-regulation as a systemic process which requires a holistic approach to the study of selfregulatory systems (Shapiro & Schwartz, 2005). We also access the body of research on school effectiveness which suggests that schools offering higher (advanced) and lower educational curricula (also called tracks or streams), differ with respect to several characteristics such as school and social climate, teacher ideology, classroom practice; and that these differences contribute to differences in academic achievement even when student background characteristics such as ability and socio-economic status are controlled for (Opdenakker & Van Damme, 2006). Our interest in this body of work is related to the assumption that different educational environments can predispose those immersed in such an environment to structure their experiences of positive mood and self-regulation differently.

Much research in SR has focused on a cognitive, rational model of SR focused on goal attainment (Karoly, Boekaerts, & Maes, 2005), while the motivational and emotional beliefs that mediate students' engagement in learning have been investigated less systematically (Pintrich, 2000a) and the role of positive emotions in SR even less so (Pajares (2001)). Thus, we have drawn on research in the field of positive psychology (Snyder & Lopez, 2005) to investigate the relevance of positive subjective experiences to the process of self-regulation. Positive psychology research generally focuses on three areas in inquiry, namely *subjective experiences of the past* (well-being and life satisfaction), of the *present* (happiness and flow) and the *future* (optimism and hope); *individual factors* such as resilience and courage; and *institutional factors* such as responsible citizenry and work ethic (Snyder & Lopez, 2005). Thus, positive psychological constructs refer to those constructs that can be aligned with the three areas within positive psychology and that represent a conscious shift away from the study of pathology and weakness towards the study of human strengths and assets.

2. Positive mood in self-regulation

In this study, we have chosen to focus on positive mood by incorporating optimism and hope as indicators of subjective experience, and resilience, confidence and persistence as indicators of individual factors in positive psychology. We argued that these factors could be important indicators when investigating participants' experience of their educational environments as suggested by school effectiveness studies in Flanders. Pajares (2001) has pointed out there has been little, if any, systematic research which focuses on integrating positive mood constructs such as *optimism* and *authenticity* with educational literature and inquiry. The field of school psychology in particular has been slow to adopt a positive orientation, this despite findings on the study of positive emotions and mastery that seem to point to obvious advantages in terms of self-regulation and academic achievement (Chafouleas & Bray, 2004). Accumulating evidence suggests that positive mood can facilitate adaptive self-regulation through beneficial effects on decision-making processes by (1) enhancing information-processing and (2) resulting in increased effort towards goal-completion (Aspinwall, 1998). Also, Eftklides and Petkaki (2005) have reported how positive mood has significant effects on students' metacognitive experiences during a mathematical problem-solving task. There are also indications that adolescents who have positive future expectations tend to be more persistent and to outperform those who have less favourable future expectations (Leondari, Syngollitou, & Kiosseoglou, 1998). Pajares (2001) reported that positive psychology variables (optimism, authenticity and invitations) were stronger in high-achieving students than low-achieving students and reported significant positive associations between self-regulation and optimism, self-concept and authenticity. In addition, Choi (2005) has demonstrated a significant association between specific self-efficacy beliefs and academic achievement. The association between self-efficacy and self-regulation is generally well-established and accepted, as self-efficacy influences the goals that students set for themselves, the efficiency of their problem-solving efforts and their decision-making (Linares et al., 2005; Maddux, 2005).

Positive mood constructs that have been demonstrated to show a positive relationship with academic achievement and which are therefore important from a self-regulated learning point of view, include *hope* (Snyder, 2002; Snyder, Rand, & Sigmon, 2005), *life satisfaction* (Park, 2005), *optimism* (Jenson, Olympia, Farley, & Clark, 2004; Roberts, Brown, Johnson, & Reinke, 2005), and *resilience* (Margalit, 2003). From a self-regulation point of view, these constructs are interesting because their definitions generally address some aspect of self-regulation explicitly. For example, Snyder (2002) defines *hope* as a construct involving goal-pursuit, agency thinking and pathways thinking, issues which are central to self-regulation. Definitions of *resilience* vary greatly but generally involve aspects that are pertinent to self-regulation, namely self-efficacy, positive problem-solving skills and selfmastery (Masten & Reed, 2005; Richardson, 2002). Goals, which form the backbone of the study of self-regulation, are considered central to the study of *optimism* because optimism facilitates the adaptive regulation of critical life situations and personal goals (Wrosch & Scheier, 2003).

Despite the seemingly obvious relevance of positive mood to self-regulation, it appears that the literature on self-regulated learning has not been influenced much by it. In an international review of SR research in three settings, namely educational psychology, industrial/organisational psychology and clinical health psychology, Karoly et al. (2005) noted we still have an inadequate understanding of the relationship between personal belief and attributional systems and individuals' self-regulatory capacities and skills. They argue for greater understanding of the mechanisms that propel the regulatory process forward, especially in the face of intrapsychic and interpersonal obstacles. Some of the constructs associated with self-regulation, such as self-efficacy, motivation and persistence are lively areas of inquiry in a positive psychology context and although positive mood states have been associated with positive learning outcomes, these results seem to have had limited impact on SR research agendas.

Greater attention to the study of positive emotion in self-regulation may help to establish how positive psychology constructs mediate self-regulation processes and academic achievement. The enhancing effect of positive mood on cognitive processing is acknowledged in studies focusing on responsible work behaviour (Isen & Reeve, 2005) and in classroom studies (Linares et al., 2005). Understanding how beliefs about positive mood in relation to goal attainment affect self-regulation may help to illuminate the detail of the ‘‘cognitive architecture” that Karoly et al., 2005 argued still eludes SR researchers.

Greater focus on the positive aspects of SR is also consistent with a general movement in education and psychology away from deficit-based models of human functioning to more strengths-based models in which individuals’ capacities, skills and strengths are studied and strengthened (Chafouleas & Bray, 2004; Seligman, 2005).

3. Mental models in self-regulation

Self-regulation can be viewed as a systems concept (Shapiro & Schwartz, 2005) and some believe the capacity for self-regulation is dependent on a system of self-representation (Demetriou, 2005) which broadly refers to a system’s ability to represent the self in a mental model. The notion that mental models offer a way to access and analyse the cognitive structure of participants’ network of knowledge of a phenomenon is theoretically well-grounded (Carley & Palmquist, 1992). The study of mental models in psychology has a long history in the work of George Kelly’s theory of personality (Kelly, 1955) and the use of repertory grid techniques to study people’s mental models of dichotomous constructs (Feixas, Bach, & Laso, 2004).

Research emphasising cognitive aspects of self-regulated learning have focused on the effects that instruction in self-regulation have on changes in students’ mental models as expressed through their conceptual frameworks or prior knowledge (Azevedo, Cromley, & Seibert, 2004), and the extent to which mental models can be accessed and changed to facilitate learning (Vosniadou, 1992), but understanding individual’s mental models of self-regulation and its relationship to positive mood has received less attention. One notable exception is the work of Isen and Reeve (2005) whose study of the effects of positive mood on intrinsic and extrinsic motivation and responsible work behaviour does provide some evidence of the beneficial aspects of positive mood on self-regulation.

In this study, we conceptualise mental models as global representations of one’s environment (Haberlandt, 1994) that enable individuals to make inferences and predictions that help them to understand phenomena and decide what actions to take to solve problems (Johnson-Laird, 1983). Mental models not only include approximations of phenomena, but they also contain contingencies with logarithms and heuristic strategies for problem-solving (Halford, 1993). Problem-solving is an important aspect of self-regulation and it can be described broadly as doing something that will have a particular cause (Anderson, 1990). Typically, problem-solving requires one to decide which steps to take to achieve a particular goal. One of the most basic cognitive tasks underlying such problem-solving decisions is the ability humans have to make causal inferences about the relationships between objects in the environment.

Because self-regulation is primarily defined in terms of goal-directed behaviour and the strategies that individuals follow in service of reaching goals (Boekaerts & Niemivirta, 2005; Carver & Scheier, 2005a, 2005b; Pintrich, 2000b), we expect that an understanding of students’ beliefs about the causal relationships that form the core of students’ mental models can assist in understanding how mental models direct students' choices about self-regulatory behaviours. Because we believe that mental models reflect causal beliefs about a phenomenon that are based on their epistemological beliefs, mental models allow us to examine the principles that guide individuals' dynamic decision-making towards goals (Winne, 2005b). The network of causal inferences in mental models allows one to make predictions on the basis of learned contingencies or declarative condition-action rules that in turn influence the behavioural choices we make (Halford, 1993).

As Carver and Scheier (2005a, 2005b) point out, the complex and nonlinear character of human behaviour makes anything more than general planning towards a goal unlikely, and since mental models can be described as internal representations of the world (Anderson, 1990; Carlson, 1997; Haberlandt, 1994) that can be represented as a system of concepts and relationships (Carley & Palmquist, 1992), representing mental models of a phenomenon may help to illuminate the implicit beliefs that drive decision-making in goal attainment. It may also contribute to an understanding of participants' personal belief and attributional systems and the self-regulatory capacities and skills that serve to propel the regulatory process forward (Karoly et al., 2005).

Zeidner et al. (2005) have pointed out that we know relatively little about the relationships between self-regulation and other variables. Arguing for a greater fusion of Eastern and Western philosophies that emphasise the role of ‘‘intention" or "mindfulness" in selfregulation, Shapiro and Schwartz (2005) have suggested a more holistic and systemic approach to self-regulation. With that in mind, we think it makes sense to question how individuals perceive self-regulatory processes in relation to positive mood. Thus, an investigation of participants' mental models may accomplish two things: First, mental models may help to make participants' implicit inferences more explicit and directly available. Second, it can offer a systemic view of positive mood and self-regulation in terms of perceived causal relationships.

Reasoning about causality is central to problem-solving (Anderson, 1990) and causal domain knowledge is thought to provide the medium for problem-solving in a domain (Carlson, 1997). Thus, how participants perceive causality in a context can indicate how they problem-solve in that context. Recently, Griffiths and Tenenbaum (2005) have argued persuasively that causal induction in human judgment reflects the ability to detect the existence of relationships between variables rather than reflecting the strength of causal relationships (based on probabilities). They demonstrate that their causal support theory (based on detecting the existence of a causal relationship only) is more consistent with human reasoning in a variety of contexts than other probability theories. Thus, requiring participants to detect and indicate the existence of a relationship between variables is consistent with Griffiths and Tenenbaum's (2005) model of causal reasoning. The variant of Interactive Qualitative Analysis (IQA) (Northcutt & McCoy, 2004) used in this study requires participants to detect the existence of a causal relationship between two variables. It was therefore judged to be suitable for eliciting the kind of reasoning inherent to human reasoning as described by Griffiths and Tenenbaum (2005).

4. Method

4.1. Research question

The research question in this study was formulated as follows: Do students perceive causal relationships between aspects of positive mood and self-regulation? In addition, we were particularly interested in establishing what participants' mental models of positive mood in relation to self-regulation would reveal in terms of the complexity of causal relationships and whether there would be differences in the way students from two distinct school environments structure their mental models. Because we conceptualise self-regulation as a dynamic, nonlinear system consisting of a network of relationships reflecting individual's perception of the causal relationships that form the core of an individual's choice of behavioural strategies in goal-pursuit, we decided to use IQA as a means of illustrating participants' mental models of positive mood and self-regulation. In contrast to the bipolar strategy of repertory grid techniques which requires participants to rate constructs by comparing and contrasting them (Marsden & Littler, 1998; Senior, 1996), IQA requires participants to judge how constructs are related in terms of cause-and-effect.

IQA may have some advantages over traditional questionnaires because it allows a detailed analysis of the complete set of assumptions that participants have of all possible relationships between all iterations of variables under consideration, making it a systematic and thorough way of examining and illustrating mental models. Thus, it is not possible for some relationships to remain unexplored. In terms of the data analysis method, an audit trail is created where each step and decision in the analysis is accounted for (Northcutt & McCoy, 2004). Also, data analysis is uncontaminated by any subjective interpretation from the researcher, so the results represent the participants' mental model and not a mental model based on the investigator's interpretation of the patterns in the data. Thus, by indicating how various constructs are causally related, participants are conducting their own theoretical coding of the construct. In contrast, thematic analyses usually require the researcher to search for meaningful chunks in verbal data and then to search for patterns in the data that are used to build a plausible theory, either inductively (bottom-up, grounded theory approach) or deductively (top-down, theoretical coding approach) (Braun & Clarke, 2006). The resulting theory is the product of the researcher's meaning-making of the data and as such, is contaminated by the researcher's worldview and assumptions about the data. Although member-checking is often used as a strategy to enhance validity of the researcher's interpretation, the inherent power difference and the abstract nature of the interpretation makes it highly unlikely that a research participant will question the researcher's interpretation of the data. With IQA, the usual issues of subjectivity and validity are less problematic because the participants code their data, not the researcher.

Finally, representing the data as a mental model of the participants' experiences about positive subjective experiences and self-regulation helps to illustrate the systemic nature of self-regulation (Shapiro & Schwartz, 2005) and lends itself well to an illustration of the dynamic feedback systems in self-regulation as suggested by Butler and Winne (1995). Some disadvantages of the IQA model is that it does not allow the usual quantitative analyses about group or individual differences in scores but since the objective of this study was not the analysis of individual variation, this does not pose a serious problem.

4.2. Research setting

The study was conducted in the Dutch-speaking region of Belgium (Flanders) where secondary education is structured along different curricular tracks. Some schools offer general secondary education (ASO) which prepares students for entry to higher education, and other schools offer technical or vocational secondary education (TSO/BSO) which mainly prepares students for a vocation or professional studies. A small percentage of schools also offer a predominantly art-based curriculum (KSO) but these schools were not represented in our sample. Flemish researchers generally agree that ASO schools generally offer a more advanced [higher] curriculum than TSO/BSO schools (Van Damme, De Fraine, Van Landeghem, Opdenakker, & Onghena, 2002; Van de Gaer, Pustjens, Van Damme, & De Munter, 2006). The results of school effectiveness studies conducted in Flanders have demonstrated that school type (ASO or TSO/BSO) has a significant impact on factors such as school and social climate, teacher expectations and peer relations (Opdenakker & Van Damme, 2006). For example, Van de Gaer et al. (2006) have pointed out that students in high educational tracks (ASO in this case) are more likely to experience an enriched learning environment, have access to more qualified teachers who have higher expectations and more favourable perceptions of them and also have friends who reinforce positive attitudes toward school. Berends (1995) has pointed out that evidence seems to support the hypothesis that tracking leads to polarisation of attitudes, where students in the lower tracks (TSO/BSO in this case) may be more predisposed to developing negative school attitudes characterised by a general tendency to resist and undermine the school's rules. Based on this evidence, we thought it would be interesting to investigate whether students from different tracks conceive of the relationship between positive mood and self-regulation differently, especially since current research on wellbeing and tracking in a Flemish context seems to support the differentiation–polarization theory (Van de Gaer et al., 2006). Also, theoretical models of self-regulation in academic contexts do not really address the possible effects that different school environments may have on the development of self-regulatory behaviours.

4.3. Participants

Students at two schools with a total population of 1050 students completed a questionnaire (TSO/BSO school; $n = 63$; ASO school; $n = 65$) which was based on the principles of Northcutt & McCoy's (2004) method of Interactional Qualitative Analysis IQA. To minimize intrusions in their instruction time, students completed the questionnaires in class under the supervision of a teacher when they had a free period. The group of 128 participants (12% of the available sample) consisted of 57 males (44.9%) and 70 females (55.1%) with one missing value (0.8%). There were no significant differences in the distribution of responses for males and females (Pearson Chi-square, $p = 0.05$). Because the IQA approach requires the analysis of data according to how a particular group (called a constituency) views the phenomenon, analysis of the data was done on school level because the participants from each school form a unique constituency by virtue of the fact that they share a common experience. Thus, in IQA, representivity refers to a participant having personal experience of the constructs under study from a particular point of view as a result of their affiliation to a certain group. In contrast, the classical, statistical view of representivity refers to the similarity between the characteristics of the sample in relation to the population from which it was drawn. The purpose of an IQA is to determine how a group of people would represent their experiences in a system of cause-and-effect and sample sizes of 10–25 are usually considered as more than adequate, especially when focus groups are conducted as this is more manageable (Northcutt & McCoy, 2004). We used a larger sample because the format of our study utilised questionnaires instead of focus groups and manageability is less of an issue, but because IQA does not rest on the usual assumptions necessary for statistical analysis, the actual size of the sample is of lesser importance.

4.4. Procedure

IQA methodology requires participants to consider how certain constructs, also called affinities[1] (Northcutt & McCoy, 2004), are related in a system of cause-and-effect relationships. Usually, focus groups are used to generate themes (called affinities), especially when the research is exploratory and the investigator does not have a clear idea of the relevant constructs that will emerge. Affinities are the product of the members of the focus group's perception of their experiences and do not necessarily correspond to theoretical constructs. In this study, we identified 10 theoretical constructs on the strength of a literature review and their salience in a recent published volume on positive psychology research (Snyder & Lopez, 2005) and self-regulation research (Zeidner et al., 2005).

Taking the research question into account, we chose *Optimism [Opt]* (Carver & Scheier, 2005a, 2005b), *Hope [Hp]* (Snyder, 2002), *Resilience [Res]* (Masten & Reed, 2005), *Confidence [Con]* (Maddux, 2005) and *Persistence [Per]* (Nix, Ryan, Manley, & Deci, 1999) to represent the positive mood constructs, and *Motivation [Mot]* (Rawsthorne & Elliot, 1999), Social support [Ss] (Boekaerts et al., 2005), *Problem-solving [Ps]* (Heppner & Lee, 2005) and *Learning goals [Lg]* (Boekaerts & Niemivirta, 2005) to represent key aspects of self-regulated learning. *Academic performance [Ap]* was selected since it can be considered an important objective/outcome of self-regulated learning.

Statements targeting the 10 constructs were developed and presented to the participants in a questionnaire format. Special care was taken to ensure that items were short, simple and written in the active voice to facilitate comprehension. Examples of the items (translated from Dutch to English to facilitate understanding) are presented in Table 1 [at end of article].

Items were scrambled to avoid fatigue and boredom which may lead to unwanted response styles. Participants were required to consider 45 statements with three options representing three possible relationships between two constructs. All possible combinations between the constructs were included in the questionnaire. Consistent with Griffiths and Tenenbaum's (2005) model of causal support in human judgment,

[1] In their text Northcutt and McCoy (2004) refer to ''affinities'' to demonstrate how responses generated by focus group members are associated to form categories. We prefer to use the term ''construct'' because the constructs under consideration were not generated in a focus group format and to remain consistent with the literature on mental models.

participants were required to choose an option reflecting the existence and the direction of a particular rela-tionship between pairs of variables (e.g. A influences B: A → B or B influenced A: B ←A) or indicating the absence of any relationship at all (A <> B), thus requiring participants not to judge the strength of a relationship, but merely the existence and direction of the relationship.

For this study, the frequency distribution of votes [i.e. the number of times a relationship between two constructs were endorsed] for the construct pairs indicated a total of 2456 votes from the TSO/BSO school sample and a total of 2482 votes from the ASO school sample distributed over the 90 construct pairs, with virtually no missing data. All three types of relationships were taken into account and there were no instances in which participants indicated an absence of a relationship (A <> B) between a construct pair. In cases where participants endorse the ‘‘no relationship” option with high frequency, it may be regarded as an indication that the participants do not have the experience with the constructs that will allow them to judge causality. In such cases, either the participants or the constructs may have been selected poorly.

The distribution of the votes among constructs was calculated, sorted in descending order and a Pareto analysis was conducted (Juran, 1962; Northcutt & McCoy, 2004) (Tables 2 and 3, [at end of article]). The Pareto principle is mostly known in an economic context where it refers to the principle that, in an organisation for example, 80% of the profits will roughly be generated by 20% of the accounts. Or, in terms of wealth distribution, that 20% of a population will account for 80% of the wealth in that population. In IQA, the Pareto analysis is used to determine the minimum number of relationships to be included in the eventual participants' mental model that explains the maximum amount of variation in the system (Juran, 1962; Northcutt & McCoy, 2004). It is based on the same 80/20 assumption that roughly 20% of the relationships will be sufficient to analyse and explain 80% of the variance in that particular group's opinion.

For both samples, the first 63 relationships explain 80.9% (TSO/BSO) and 80.2% (ASO) of the variance, respectively, and consequently these relationships were selected to be included in the representation of their mental models. A conflict analysis was conducted next (Northcutt & McCoy, 2004) to identify construct pairs with votes in opposing directions. In the current sample, the following conflicts were identified for the TSO/BSO and ASO school samples (Tables 4 and 5, respectively, [at end of article]).

From the relationships involved in conflicts, the relationships with the higher frequency was chosen in this step to construct an inter-tabular relationship diagram for each sample, while ignoring remaining relationships until they are reconciled in the final mental model (Northcutt & McCoy, 2004). The inter-tabular relationship diagram is constructed by recording the relationship for each pair of constructs twice with an arrow indicating the direction of the relationship. Delta values are calculated by subtracting the number of arrows facing inward (left) from the number of arrows facing outward (up). Deltas with positive values are noted as *drivers* (causes) and deltas with negative values are noted as *outcomes* (effects) (Northcutt & McCoy, 2004).

The inter-tabular relationship diagrams for the TSO/BSO and ASO school samples are provided in Tables 6 and 7, respectively [at end of article].

Once deltas have been calculated, constructs are sorted in decreasing order of delta frequency to identify the relative drivers (causes) and outcomes (effects) in the system as shown in Tables 8 and 9, respectively [at end of article].

Primary drivers and outcomes are identified by taking two rules into account. First, the driver with the highest amount of ‘‘outs” regardless of the number of ‘‘ins” is designated the primary driver. Second, even if a driver may not have the highest number of ‘‘outs”, if it has zero ‘‘ins” it is shifted to the top of the inter-tabular relationship diagram and designated the primary driver. A primary driver with zero ‘‘ins” influences other constructs in the system, but is not influenced directly by other constructs. The same rules hold for the identification of primary outcomes, with the exception that one now considers the highest amount of ‘‘ins” and the presence of zero ‘‘outs”. All other drivers and outcomes are secondary. *Pivots* are constructs that have an equal number of ‘‘outs” and ‘‘ins”, placing it in the middle of the system as a construct that equally influences as it is influenced by other constructs.The inter-tabular relationship diagram was used to draw the mental model by means of *Inspiration Software* (Version 7.6). Constructs were arranged in order of delta and the relationships for all the construct pairs as indicated in the inter-tabular relationship diagrams were carried over and depicted visually, resulting in cluttered systems influence diagrams for the two school samples as presented in Figs. 1 and 2, respectively [at end of article].

Because the systems influence diagrams are too complex to be meaningful, a simpler, more parsimonious representation is sought by identifying and eliminating redundant links and this is done according to delta value. The basic principle is that the links that the construct with the highest delta value (generally the primary driver) has with all other constructs are investigated first (from lowest delta value to higher delta value, thus progressing from right to left), the construct with the second highest delta value was selected next, and so on. It is also during the process of eliminating redundant links that the lower frequency in construct pairs involved in conflicts, are reconciled by adding the link with the lower frequency if it is not already represented in the system. In this way, all views not just the majority of the views, are finally represented. If the elimination procedure is followed meticulously, only one representation of the system is possible. This has obvious advantages for the reliability of the findings, since it is impossible for two investigators, using the same method correctly, to arrive at different representations of the system. Tables 10 and 11 [at end of article] show the steps in the elimination of redundant links for both samples.

The process of eliminating redundant links resulted in a cleaner representation of the relationships between constructs and these are presented in Figs. 3 (TSO/BSO school) and 4 (ASO school), respectively.

Figs. 3 and 4 [at end of article] show the mental models of the TSO/BSO and ASO school samples, respectively, and these will form the basis of the discussion in the next section.

5. Results

In this study, we were interested in exploring how students structure their understanding of positive mood and self-regulation in a system of cause-and-effect. We used IQA to allow us to draw mental models of students' understanding of the causal relationships. In the next section we will follow a surface approach in our analysis by discussing significant aspects in the appearance of the mental model, but a broader interpretation of the possible meaning of the mental models will be addressed in the discussion.

5.1. The identification of drivers and outcomes

There are virtually no published studies utilising an IQA approach which makes it rather difficult to draw on an existing body of knowledge when describing the data. Thus, to facilitate the process of comparing the mental models of the two school samples, the first author (SHV) designed a crude measure for calculating a similarity score (SS) based on five basic characteristics, namely the presence of (i) a primary driver, (ii) a primary outcome, (iii) pivot, (iv) number of similar secondary drivers, and (v) number of similar secondary outcomes. These five characteristics are used to describe the mental model and to assign the positions of the constructs and as such it can be argued that they ‘‘define" the distinct character of the mental model. So, for example, if the two samples had similar drivers a value of 1 was assigned. This was also done when comparing the outcomes and pivots. To compare the secondary drivers and outcomes, agreement was expressed proportionally. Thus, if three out of the four secondary drivers were the same, it was expressed as an agreement of 0.75. Finally, the similarity score was calculated by obtaining the average of the scores.

The comparison of the two samples' mental models is presented in Table 12 [at end of article].

From Table 12, it is evident that the similarity score (SS) for the two samples is 0.70, indicating an apparently significant degree of similarity in terms of the five salient characteristics of the mental model. Thus, in the mental models for both schools, participants identified *Academic performance* as primary driver and *Learning goals* as a primary outcome. Both samples describe *Optimism, Problem-solving* and *Social support* as drivers, and *Hope, Resilience* and *Motivation* as outcomes. Exceptions are *Persistence*, which is viewed by the TSO/BSO school sample as a driver and by the ASO school sample as an outcome, and *Confidence*, which is indicated as an outcome and a pivot for the respective samples. However, a complete comparison of both mental models must also take into account how the constructs in the mental model are organised in relation to each other and this can be accomplished by inspecting the number and nature of the feedback systems in the mental model.

5.2. Feedback systems

Feedback systems are created when a path exists that feeds back the influence of a construct to itself, creating a recursive feedback loop. Feedback systems form when a construct has more than two arrows flowing either toward or away from it, creating a feedback point between constructs in the system. This can occur in three different ways. The first type of feedback point, which we shall name a *balanced feedback point*, is created when one of the constructs involved in a recursive feedback loop has two outward and two inward arrows, indicating that its influence is directed via two other constructs in the system and fed back again via two different paths. Balanced feedback points usually create neighbouring feedback systems that interact with each other via one construct. The second kind of feedback point is a *convergent feedback point* which is formed when one of the constructs in a recursive feedback loop has two inward pointing arrows and only one outward pointing arrow, suggesting a concentration effect of more than one construct's influence to one other construct in the system. The third kind of feedback point can be called a *divergent feedback point* because it consists of at least one construct in a recursive feedback loop with one inward pointing arrow and two outward pointing arrows, suggesting a diluting/divergent effect of one construct's influence to the rest of the system. Convergent and divergent feedback points do not create neighbouring feedback systems, rather they give rise to enmeshed and/or embedded systems that interact with each other via two or more constructs.

When we inspect the mental models of the two schools in our sample, we see that the mental model of the TSO/BSO school sample consists of two balanced feedback points (*Problem-solving* and *Persistence*), one convergent point (*Confidence*) and one divergent point (*Hope*), linking three neighbouring feedback systems, one of which contains an embedded feedback system. On the other hand, the mental model of the ASO school sample consists of two convergent feedback points (*Problem-solving* and *Motivation*) and one divergent feedback point (*Persistence*), linking two feedback systems which are enmeshed via two constructs (*Motivation* and *Persistence*). Taking into account the number and kind of feedback systems in the two samples, we suggest that despite superficial similarities in the key characteristics of the mental models in both samples, there appear to be significant differences in the organisation of the constructs in terms of their influence on other constructs in the system. We do not yet know the full implications of the different kinds of systems in terms of how the organisation of those feedback systems will influence participants' ultimate behavioural choices, but we hypothesise that neighbouring and embedded feedback systems will give rise to more cognitive complexity in the organisation of the mental models than enmeshed feedback systems, which appear to be more consistent with a linear flow of information.

5.3. Qualitative causal pathway analysis

To conduct an even more detailed analysis, the mental models were compared by examining the constructs involved in causal paths to establish whether superficial similarities in the mental models were supported or contradicted by a more detailed analysis of causal pathways. In doing so, several similarities and differences in the way that some constructs are causally connected were observed.

To illustrate, both samples indicate a causal path leading from *Academic performance* to *Problem-solving*, but in very different ways. For the TSO/BSO sample the path is indicated as $[Ap^{Pd}] \rightarrow [Op^{Sd}] \rightarrow [Ps^{Sd:BF}]$[2] and for the ASO sample it is indicated as $[Ap^{Pd}] \rightarrow [Ps^{Sd:CF}]$.[3] Similarly, the causal path from *Problem-solving* to *Confidence* is the same for both schools on a superficial level, but very different when the organisation of the constructs is taken into account. Thus, the causal pathway for the TSO/BSO sample is expressed as $[Ps^{Pd:BF}] \rightarrow [Ss^{Sd}] \rightarrow [Per^{Sd:BF}] \rightarrow [Con^{So:CF}]$ and for the ASO sample as $[Ps^{Pd:CF}] \rightarrow [Ss^{Sd}] \rightarrow [Op^{Sd}] \rightarrow [Con^{Pv}]$.[4] Then there are also very different paths when the two mental models are compared. For example, the causal path between *Confidence* and *Learning goals* for the TSO/BSO sample is expressed very directly as $[Lg^{Po}] \rightarrow [Con^{So}]$, whereas for the ASO sample the causal path involves at least five intermediary constructs expressed as $[Lg^{Po}] \rightarrow [Mot^{So:CF}] \rightarrow [Per^{So:DF}] \rightarrow [Ps^{Sd:Cf}] \rightarrow [Ss^{Sd}] \rightarrow [Op^{Sd}]$? $[Con^{Pv}]$. In addition, for the TSO/BSO sample *Academic performance* forms part of a neighbouring feedback system because of a recursive feedback path from *Problem-solving* to *Academic performance*, whereas the mental model of the ASO sample reflects a linear relationship from *Academic performance* to *Problem-solving* with no recursive loops. What these differences mean exactly is still unclear at this point, but we hope to eventually demonstrate a relationship between the complexity of the mental models (as expressed by the number and nature of feedback loops and the organisation of the constructs relative to each other) and the kind of academic environment that participants find themselves in.

The placement of positive mood constructs in the mental models also reflect other differences between the two samples that may be important. In the mental model of the TSO/BSO sample *Hope* is indicated as an intermediary for *Motivation* and *Persistence* in the pathway $[Mot^{So}] \rightarrow [Hp^{So}] \rightarrow [Per^{Sd}]$ whereas it is expressed as an intermediary for *Resilience* and *Learning goals* in the ASO sample as $[Res^{So}] \rightarrow [Hp^{So}] \rightarrow [Lg^{Po}]$. For both samples, *Hope* is involved in a recursive feedback loop, but involving different constructs. Taking another positive mood construct, namely *Optimism*, we see it indicated as an intermediary between *Academic performance* and *Problem-solving* as $[Ap^{Pd}] \rightarrow [Op^{Sd}] \rightarrow [Ps^{Sd}]$ for the TSO/BSO sample, and *Social support* and *Confidence* in the path $[Ss^{Sd}] \rightarrow [Op^{Sd}] \rightarrow [Con^{Pv}]$ for the ASO sample. Although *Resilience* has a causal influence on *Learning goals* in both mental models, the samples differ with respect to their preceding causal influences. For the TSO/BSO sample, the causal path is expressed as $[Hp^{So}] \rightarrow [Res^{So}] \rightarrow [Lg^{Po}]$ and for the ASO sample the causal path is expressed as $[Per^{So}] \rightarrow [Res^{So}] \rightarrow [Hp^{So}] \rightarrow [Lg^{Po}]$.

As a result of the above analysis, we can conclude that despite apparently significant similarities in the mental models of the two schools, it remains superficial and it is not

[2] This notation indicates that Academic Performance was identified as a primary driver (Pd) and Optimism and Problem-solving were identified as secondary drivers (Sd), with Problem-solving acting as a balanced feedback point (BF).
[3] This notation indicates that Problem-solving is a secondary driver that acts as a convergent feedback point (CF).
[4] This notation indicates that Confidence was identified as a pivot (Pv).

supported by a more detailed analysis of the feedback systems and the pathway analysis in the mental models. Thus, although both schools identified roughly the same constructs as drivers and outcomes, the differences in the organisation of those constructs relative to each other and the extent to which they form part of feedback systems in the mental models is significant enough to warrant the conclusion that the two samples have distinct beliefs about the ways that positive mood and self-regulation constructs are related. What the impact of those differences may be still remains to be fully explored, but we do expect that those differences may be related to different kinds of educational environments that the two types of schools offer.

6. Discussion

Before discussing the meaning of causal pathways for each constituency, a note about feedback loops and complex systems is in order. Current thinking in dynamic systems theory (Capra, 2005; Lorenz, 1993) describes complex systems in terms of nonlinear relationships which are unpredictable because of the existence of feedback loops which allow the effects of variables to feed back into the system, thus amplifying the initial effect which can have a dramatic impact on the ultimate developmental trajectory of the system. In short, small changes can have effects that are disproportionate to an initial disturbance (Capra, 2005).

Positive feedback loops tend to amplify the effects of the feedback system whereas negative feedback loops diminish the effect and restricts the path of the system (Carver & Scheier, 2005a, 2005b). A balance between positive and negative feedback systems creates the dynamic balance necessary for emerging complexity on a biological (Capra, 2005) as well as a psychological level (Shapiro & Schwartz, 2005). The mental models discussed in this study reflect a nonlinear system as far it can be defined by the presence of balanced, convergent and divergent feedback loops which allow complexity to emerge through the nonlinear flow of information. In this regard, the mental model of the TSO/BSO school is thought to reflect a more complex system because more constructs are involved in recursive relationships which have created four different feedback points resulting in three neighbouring feedback system and one embedded feedback system, creating more opportunity for constructs to influence each other. The mental model of the ASO sample has three different feedback points resulting in two enmeshed feedback systems, indicating that the flow of information in the system is limited to fewer constructs and a more linear path. It is hypothesised that complexity in a system allows the system to respond with more flexibility, responsiveness and adaptiveness since feedback loops allow a system to be more open to influences from other systems. We therefore suggest that constructs involved in recursive feedback loops will have a stronger impact on the system because their effects become input for other constructs in the system, thus amplifying their potential to impact on other variables.

Thus, far we have limited the discussion to the organisation and possible dynamics of the mental models, but we have said relatively little about the meaning of these relationships. We will now turn our attention to the meaning of the mental models in terms of positive mood and self-regulation and also offer some thoughts about the relationship with educational environment.

6.1. The meaning of causal pathways

Emphasis on the network of belief processes in mental models is considered important because the study of nonlinear living systems demands a description of the way in which mental processes enable the emergence of psychological qualities such as resilience or self-regulation. If anything, dynamic systems theory requires a closer look at processes rather than structures (Capra, 2005) and this is also acknowledged in the study of self-regulation (Carver & Scheier, 2005a, 2005b). In the following discussion, the reader should keep in mind that the nonlinearity of complex systems frequently makes it impossible to detect the original starting point of any effect in the system. Therefore, although the discussion below may indicate a construct as the starting point of one interaction, it is simultaneously the end-point of another interaction. The essence of complex, self-organising systems is that their history can be known, but not their future (Capra, 2005).

Both samples indicated Academic performance as the primary driver in their mental model. From this we conclude that both samples attach importance to attaining good grades in school. Since Academic performance is the primary driver, the concept of sensitive dependence on initial conditions (small differences in the initial conditions of a system lead to large effects through repeated iterations) suggest it is safe to assume that individual differences in participants' beliefs about academic performance may have an especially significant impact on their behavioural choices (Capra, 2005; Carver & Scheier, 2005a, 2005b).

For the TSO/BSO sample *Academic performance* is part of a recursive feedback system of three constructs ([Ap^{Pd}]→ [Op^{Sd}]→ [$Ps^{Sd:BF}$]) as opposed to the ASO sample's direct, linear pathway ([Ap^{Pd}]→ [$Ps^{Sd:CF}$]). This suggests that for the former group of participants, *Academic performance* has an important influence on their level of optimism, perhaps indicating that participants believe that those who perform academically are generally more optimistic, possibly leading to greater access to and mobilisation of problem-solving strategies. Such an interpretation would be consistent with research findings which indicate the beneficial effects of positive affect on problem-solving, particularly in terms of flexibility and creativity (Frederickson, Mancuso, Branigan, & Tugade, 2000; Isen & Reeve, 2005), as well as self-regulation as a result of training in problem-solving (Perels, Gürtler, & Schmitz, 2005).

We can also interpret the path differently. The involvement of *Optimism* (as a positive mood construct) as an intermediary for *Academic performance* and *Problem-solving* (as a self-regulation construct) may indicate that the participants of the TSO/BSO sample who come from a [reputedly] lower track educational environment, may need the buffering effects of positive mood more to mobilise their problem-solving skills and improve their academic performance, especially since it appears that students from lower tracks are more likely to develop anti-school attitudes (Van de Gaer et al., 2006). Thus, interventions focusing on the beneficial effects of optimism may help to enhance the problem-solving skills and academic performance of students in a lower educational track if they have developed an anti-school attitude. Similarly, the absence of positive mood constructs in relation to *Academic performance* in the ASO sample's mental model may indicate less concern with well-being factors in relation to self-regulation because these participants (coming form a reputedly high track educational environment) already find themselves in a positive, enriched learning environment. One may therefore expect these participants to be less focused on well-being factors in relation to self-regulation factors.

For both samples, the propensity to set *Learning goals* was viewed as a primary outcome, suggesting that goal-setting is not viewed as a starting point for goal-directed action but rather as an emergent property resulting from a dynamic balance between the all the preceding constructs. This is quite surprising since goal-setting in SRL is generally viewed as a driving force, influencing and directing our actions (Shah & Kruglanski, 2005). One explanation for this finding may be that the current study examined goal-setting purely in relation to mood constructs and that the addition of other, more cognitive constructs may result goal-setting being identified as a driver for those processes. Another explanation may be that goal-setting arising as a consequence of positive subjective states, as seems to be the case with the current data, may reflect a concern with well-being factors (ego-protective factors) rather than mastery/growth factors (Boekaerts & Corno, 2005). Indeed, for both samples *Learning goals* are shaped by motivational beliefs as expressed in the following causal pathways for the TSO/BSO sample ($[Mot^{So}] \rightarrow [Hp^{So}] \rightarrow [Res^{So}] \rightarrow [Lg^{Po}]$) and the ASO sample ($[Mot^{So}] \rightarrow [Per^{So}] \rightarrow [Res^{So}] \rightarrow [Hp^{So}] \rightarrow [Lg^{Po}]$), with *Motivation* being influenced by the dynamic balance of all the previous constructs. The data may reflect the ''self-focused interpretation'' process in self-regulation where goal-setting is believed to be shaped by motivational beliefs (Boekaerts & Niemivirta, 2005). This is different from more formal learning environments where goal-setting reflects a more conscious approach to self-regulation. Nevertheless, even though Butler and Winne (1995, p. 245) have suggested that SRL is *''the pivot upon which students' achievement turns''*, the results of this study suggest that, at least as far as goal-setting goes, the participants in both samples believed SRL to be a primary outcome dependent on the experience of positive mood states.

We also have to acknowledge that we do not know to what extent the mental models are mediated by personality and motivational factors, so we cannot directly conclude that the differences between the samples will reflect differences in participants' behavioural approach to self-regulation or their educational environments for that matter. This is not necessarily problematic if we consider that the goal of this study was to examine how two distinct groups of participants structure their experience of positive mood and self-regulation and not to determine what the possible causes of those differences might be. What we are suggesting is that there are significant differences in the ways that the two samples have structured their causal beliefs about the relationship between positive mood and self-regulation and that these differences may be partially attributable to contextual school-level factors related to the educational environment of schools who offer lower or higher track educational environments. In addition, it would be important to investigate in further research to what extent the patterns observed in these samples remain constant across educational environment.

Both samples reported differences in the way *Motivation* interacts with other constructs in the system. The TSO/BSO sample indicates *Hope* as an intermediary for *Motivation* and *Persistence*, suggesting that, for this group, motivation in itself does not necessarily lead to persistence, but that *Hope* may be an important intermediary. This may be because hope requires the presence of future goals, thoughts about ways to reach those goals (pathway thoughts) and a belief in one's capability to reach goals (agency thinking) (Snyder, 2002). When motivation is coupled with the agency and pathway thoughts characteristic of hope states, goals may seem more attainable. Motivation without hope thinking may therefore only be enough for the individual to engage in an activity initially, but not necessarily to sustain involvement over a long period of time. Carver and Scheier (2005a, 2005b) have suggested that individuals will persist longer in the face of adversity if they are motivated and if such motivation is coupled with a positive assessment of outcomes. Although there have been concerns that optimism may interfere with adaptive self-regulation, there is plenty of recorded evidence that positive affect is generally facilitating rather than constraining (Aspinwall & Richter, 1999; Isen & Reeve, 2005). In contrast, the ASO sample's mental model indicates *Hope* as an intermediary for *Resilience* and *Learning goals*. We do not know at this point which organisation reflects a more favourable situation, or indeed whether such a difference is important from a practical point of view. At the very least, we suggest that such differences may indicate different approaches to self-regulation intervention depending on the educational environment of the participants.

Another notable feature of both samples' mental models are their causal attributions about resilience since it seems to contradict the view of resilience as a driving force that helps people to overcome diversity (Richardson, 2002). Both samples viewed *Resilience* more as an outcome than a driving force. The TSO/BSO sample believed *Resilience* to be the outcome of the $[Con^{So}] \rightarrow [Mot^{So}] \rightarrow [Hp^{So}]$ feedback path. Consequently, we conclude that participants in this sample experience a sense of resiliency as a result of positive motivational, hope and persistence states. For the ASO sample, resilience is the outcome of a more direct linear causal path ($[Mot^{So}] \rightarrow [Per^{So}]$), while indirect effects from *Hope* and *Learning goals* contribute via their connection with *Motivation*. Which mental model is more desirable? The ASO sample's mental model reflects *Hope* as a state that arises from beliefs about positive within-person qualities of resilient people. *Hope* involves an interaction between agency thinking, pathway thinking and goal-attainment (Snyder, 2002) which requires qualities that are thought to be characteristic of resilient people, namely self-mastery, self-efficacy, high expectancies and positive outlook (Richardson, 2002). If *Hope* arises from within person qualities that are relatively stable in the individual, as is the case with participants from the ASO sample, then their levels of *Hope* may be less open to disturbing influences from the environment. If we consider that participants from the ASO sample come from a high track and therefore supposedly more positive and enriching environment with a tendency towards developing pro-school attitudes, then the organisation of these constructs may reflect the fact that these participants' experience of themselves as resilient may be supported and enhanced by a favourable educational environment. In contrast, the TSO/BSO sample's mental model reflects *Resilience* as being influenced by *Hope*, perhaps indicating a more vulnerable position where participants description of themselves depend to an extent on how much hope they experience. Thus, we think that the TSO/BSO sample's organisation of *Hope* and *Resilience* reflects a more vulnerable system than that of the ASO sample. We have said that mental models reflect the participants' causal beliefs about a phenomenon and the organisation of constructs in the mental model gives important clues about how participants relate constructs causally so that we have some idea about the beliefs that form the foundation of participants' decisions and goal-directed behaviours in self-regulation. As a consequence, participants from the TSO/BSO sample may be more likely to experience themselves as resilient if they are in an educational environment that supports their experience of themselves as persistent, motivated and hopeful of the future, especially if those descriptions are reinforced by a supportive social environment ([Ss^{Sd}] → [Per^{Sd}]) and feeling effective in an academic environment ([Ap^{Pd}] → [Op^{Sd}] → [Ps^{Sd}] → [Ss^{Sd}], which from current research appears not likely to be the case (Opdenakker & Van Damme, 2006). Participants from the ASO sample may experience themselves as resilient if they feel effective in an academic environment and if they receive social support that leads them to feel optimistic, confident and motivated ([Ss^{Sd}] → [Op^{Sd}] → [Con^{Pv}] →[Mo^{Sd}]→ [Per^{Sd}] which, from current research appear to be likely (Opdenakker & Van Damme, 2006). Since goal-setting is regarded as the hallmark of self-regulatory behaviour (Boekaerts & Corno, 2005; Carver & Scheier, 2005a, 2005b), finding it at the direct mercy of participants' beliefs about being resilient is perhaps less optimal but we also acknowledge that we need to conduct more research about participants' perception of the causal relationships between goal-setting and other cognitive constructs. Participants from the ASO sample indicate the belief that *Resiliency* has a direct influence on *Hope* and *Learning goals* and its effects feed back into the system with *Motivation*, indicating that their beliefs of resilience may not only affect their tendency to set learning goals, but also affect their motivational levels, which in turn also affects *Problem-solving* via *Persistence*.

Overall, we think that the ASO sample's more linear mental model and less feedback loops would make intervention in SRL more challenging because participants' causal belief system is more dependent on a specific, uni-directional flow of information with less opportunities for constructs to influence each other, making it more robust. We can therefore speculate that the effort that participants put into a learning task will have a positive influence on their problem-solving ([Per^{Sd}] → [Ps^{Sd}]), but only in so far as Persistence is positively influenced by a positive flow of information in the [Ps^{Sd}] → [Ss^{Sd}] → [Op^{Sd}] → [Con^{Pv}] → [Mot^{So}] causal pathway. Put differently, one might say that, for the participants in this school, the prerequisite input to persist at a task is much more delicate in the sense that it requires the educational environment to support the ‘‘right” input from no less than six constructs. Since the feedback loop does not contain smaller, embedded feedback loops, the potential for smaller feedback loops to potentially affect and correct negative feedback in the larger feedback system, is limited, making it fairly resistant to change.

7. Summary and limitations

At the most basic level, the findings of this study suggest enough reason to merit further investigation of the association between positive mood and aspects of self-regulation. The mental models of both schools indicate that participants believe positive mood and self-regulation to be causally related. The mental models for the two samples also suggest that participants in the two samples structure their experiences differently, although the implications of conclusion is subject to argument because there is not enough data to support the argument that these differences might translate in participants' behavioural choices, if at all. For the moment, we assume that mental models form the ‘‘filter” or ‘‘blueprint” for our decisions and behaviours (Johnson-Laird, 1983) and as such we think it may be important to further examine the extent to which positive emotions can impact on individuals' self-regulatory behaviours. In addition, the findings of this study may be of interest to researchers in the field of personal epistemology. Personal epistemology refers to the beliefs that individuals' have about knowledge and learning and which have been demonstrated to affect their academic achievement (Lodewyk, 2007). Although epistemological beliefs initially referred only to beliefs about knowledge, this conceptualisation was later challenged and expanded to include beliefs about learning, speed of learning as well as ability to learn (Schommer-Aikins & Easter, 2006). In addition, Bra˚ten & Strømsø (2005, p. 543) suggested that ‘‘epistemological beliefs may function as implicit theories that can give rise to goals for learning and guide the selection of self-regulatory strategies” Thus, epistemological beliefs generally take into account the ways in which beliefs about knowledge and learning enhance or constrain the choice and pursuit of goals, as well motivation (Hofer & Pintrich, 1997). From a cognitive perspective, Winne (2005b) believes that a better understanding of the cognitive act of decision-making and the factors that students consider when choosing and pursuing goals, is needed. We suggest that the IQA methodology may make an interesting contribution to our understanding of students' epistemological beliefs in relation to self-regulation, especially since it has been demonstrated that perceptions about the academic environment are causally related to study behaviour (Richardson, 2006).

Both schools' participants indicated that they viewed *Academic performance* as the main driver and *Goal-setting* as the main outcome for self-regulation indicating that they place a high premium on academic achievement. Such findings may suggest a tendency toward extrinsic motivation but this conclusion needs to be backed up by further study in which the mental models of participants with different levels of motivation are investigated. Nevertheless, from a motivational achievement perspective, participants appear to be more performance goal oriented than learning goal oriented. Reliance on learning goal-orientation is generally associated with more adaptive patterns of self-regulation, more persistence (Radosevich, Vaidyanathan, Yeo, & Radosevich, 2004), increased memory recall and deeper cognitive processing (Patrick, Ryan, & Pintrich, 1999).

It must be noted that we targeted specific variables related to positive mood and the mental models that were presented are by no means meant to be comprehensive representations of students' understanding of the SR construct. The mental models should be supplemented and expanded by future studies in which students' mental models of other variables related to SR are studied. For example, it may be especially informative to examine students' mental models of SR and variables related to formal and informal learning environments, the impact of the learning environment on the development of SR, personal factors such as personality and cognitive styles or even students mental model of the structure of SR.

A significant limitation of this study is that we did not examine specific hypotheses related to participants' beliefs as they are represented in the mental models and the extent to which they may correlate with other more formal measures of self-regulation and positive subjective states. However, the main principle behind the IQA approach is that it provides a way to examine the beliefs of a group of participants who share similar experiences about an issue. Thus, the usual assumptions about variability in the data do not apply. This does not mean that participants may not have different views, and that those differences cannot be captured in the analysis of the relationships. One of the strengths of IQA data analysis is that the process allows the views of all participants to be reflected and not just those that are statistically significant.

Based on the lack of published data on IQA, and considering the fact that we do not yet know how the IQA analyses would compare with more classical statistical approaches to data analysis, one interesting possibility for further enquiry would be to compare participants' responses on classical self-report measures with their causal attributions on the same constructs in an IQA study. It would be interesting to see to what extent a correlational analysis would mirror students causal attributions as recorded in the mental model. Of course, it remains questionable whether the mental models as they are depicted by the results of this study reflect a fairly stable representation of participants' understanding of the topic under study, or whether it may be susceptible to environmental influences. Mental models are generally thought to be fairly resistant to change (Anderson, 1990), but further investigation of the extent to which the particular methodology used in this study yields reliable, stable representations of participants' mental models is highly recommended.

In conclusion, we think that the IQA approach offers a different way of examining what participants come to believe on the basis of their experiences. We think that it can supplement studies utilising statistical analyses because it asks different questions about the data. Classical measures may indicate to what extent participants can be described as optimistic, motivated or self-regulated, but by examining participants causal beliefs can we get a clearer picture of the conditions under which those descriptions will be activated and used as an interpretive and evaluative framework to guide decision-making in learning encounters as suggested by Winne (2005b).

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Table 1
Sample items from the IQA questionnaire

1.	If I am optimistic, it will be easier to set learning goals for myself	A
	If I set learning goals for myself, it will be easier for me to be optimistic	B
	Being optimistic and setting learning goals do not influence each other	C
2.	When I persist, I will achieve good marks	A
	Achieving good marks will help me to persist in learning	B
	Persistence and achieving good marks do not influence each other	C

Table 2
Pareto analysis—TSO/BSO school sample

Affinity pair relationship		Frequency sorted (descending)	Cumulative frequency[a]	Cumulative percent[b] (relation)	Cumulative percent[c] (frequency)	Power[d]
1	Con ← Ap	48	48	1.1	2.0	0.8
2	Opt ← Ap	46	94	2.2	3.8	1.6
3	Hp ← Ap	45	139	3.3	5.7	2.3
4	Hp ← Ps	43	182	4.4	7.4	3.0
5	Ps ← Per	43	225	5.6	9.2	3.6
6	Mot ← Ap	40	265	6.7	10.8	4.1
7	Lg ← Mot	40	305	7.8	12.4	4.6
8	Hp ← Mot	38	343	8.9	14.0	5.1
9	Ss → Res	37	380	10.0	15.5	5.5
10	Mot ← Ss	37	417	11.1	17.0	5.9
11	Ap → Per	37	454	12.2	18.5	6.3
12	Opt → Res	37	491	13.3	20.0	6.7
13	Mot ← Ps	37	528	14.4	21.5	7.1
14	Lg ← Hp	37	565	15.6	23.0	7.4
15	Mot ← Con	36	601	16.7	24.5	7.8
16	Res ← Ap	36	637	17.8	25.9	8.2
17	Con ← Ps	36	673	18.9	27.4	8.5
18	Hp ← Ss	35	708	20.0	28.8	8.8
19	Opt → Con	35	743	21.1	30.3	9.1
20	Lg ← Ss	34	777	22.2	31.6	9.4
21	Opt → Hp	34	811	23.3	33.0	9.7
22	Opt → Per	33	844	24.4	34.4	9.9
23	Ss ← Con	33	877	25.6	35.7	10.2
24	Opt → Ps	33	910	26.7	37.1	10.4
25	Hp → Res	33	943	27.8	38.4	10.6
26	Lg ← Opt	32	975	28.9	39.7	10.8
27	Opt ← Ss	32	1007	30.0	41.0	11.0
28	Opt → Mot	32	1039	31.1	42.3	11.2
29	Mot ← Per	32	1071	32.2	43.6	11.4
30	Ss ← Ps	31	1102	33.3	44.9	11.5
31	Res ← Ps	31	1133	34.4	46.1	11.7
32	Ps → Ap	31	1164	35.6	47.4	11.8
33	Lg ← Ap	30	1194	36.7	48.6	11.9
34	Hp ← Con	30	1224	37.8	49.8	12.1
35	Ss → Per	30	1254	38.9	51.1	12.2
36	Lg → Con	30	1284	40.0	52.3	12.3
37	Ss ← Ap	29	1313	41.1	53.5	12.3
38	Con ← Per	29	1342	42.2	54.6	12.4
39	Mot → Res	29	1371	43.3	55.8	12.5
40	Mot → Per	28	1399	44.4	57.0	12.5
41	Opt ← Hp	28	1427	45.6	58.1	12.5
42	Hp → Per	28	1455	46.7	59.2	12.6
43	Res → Con	28	1483	47.8	60.4	12.6
44	Opt ← Mot	28	1511	48.9	61.5	12.6
45	Con → Per	28	1539	50.0	62.7	12.7
46	Lg ← Ps	28	1567	51.1	63.8	12.7
47	Mot ← Res	28	1595	52.2	64.9	12.7
48	Lg ← Per	27	1622	53.3	66.0	12.7
49	Ap ← Per	27	1649	54.4	67.1	12.7
50	Hp ← Per	27	1676	55.6	68.2	12.7
51	Res ← Per	27	1703	56.7	69.3	12.7

Table 2 (*continued*)

Affinity pair relationship		Frequency sorted (descending)	Cumulative frequency[a]	Cumulative percent[b] (relation)	Cumulative percent[c] (frequency)	Power[d]
52	Lg → Per	27	1730	57.8	70.4	12.7
53	Ss ← Per	25	1755	58.9	71.5	12.6
54	Lg ← Res	25	1780	60.0	72.5	12.5
55	Opt ← Per	25	1805	61.1	73.5	12.4
56	Opt → Ss	24	1829	62.2	74.5	12.2
57	Ss → Ap	24	1853	63.3	75.4	12.1
58	Res ← Con	24	1877	64.4	76.4	12.0
59	Hp ← Res	23	1900	65.6	77.4	11.8
60	Opt ← Ps	23	1923	66.7	78.3	11.6
61	Ss → Ps	23	1946	67.8	79.2	11.5
62	Lg → Ap	23	1969	68.9	80.2	11.3
63	Lg ← Con	22	1991	70.0	81.1	11.1
64	Ss → Con	22	2013	71.1	82.0	10.9
65	Hp → Mot	21	2034	72.2	82.8	10.6
66	Res → Ps	21	2055	73.3	83.7	10.3
67	Opt ← Res	21	2076	74.4	84.5	10.1
68	Lg → Ps	20	2096	75.6	85.3	9.8
69	Mot → Ap	20	2116	76.7	86.2	9.5
70	Ps ← Ap	19	2135	77.8	86.9	9.2
71	Mot → Con	19	2154	78.9	87.7	8.8
72	Mot → Ps	19	2173	80.0	88.5	8.5
73	Ss ← Res	19	2192	81.1	89.3	8.1
74	Res → Ap	19	2211	82.2	90.0	7.8
75	Con → Ps	18	2229	83.3	90.8	7.4
76	Lg → Mot	18	2247	84.4	91.5	7.0
77	Mot → Ss	18	2265	85.6	92.2	6.7
78	Hp → Con	17	2282	86.7	92.9	6.2
79	Res → Per	17	2299	87.8	93.6	5.8
80	Lg → Hp	16	2315	88.9	94.3	5.4
81	Lg → Ss	16	2331	90.0	94.9	4.9
82	Hp → Ps	15	2346	91.1	95.5	4.4
83	Opt ← Con	15	2361	92.2	96.1	3.9
84	Lg → Res	15	2376	93.3	96.7	3.4
85	Hp → Ss	15	2391	94.4	97.4	2.9
86	Ps → Per	13	2404	95.6	97.9	2.3
87	Con → Ap	13	2417	96.7	98.4	1.7
88	Opt → Ap	13	2430	97.8	98.9	1.2
89	Hp → Ap	13	2443	98.9	99.5	0.6
90	Lg → Opt	13	2456	100.0	100.0	0.0

[a] The running total of votes for each affinity pair.

[b] Based on the number of possible relationships (90), each relationship represents 1/90 or 1.1% of the total.

[c] Cumulative percentage based on the percentage of the number of votes cast (4989).

[d] Index of the degree of optimisation of the system (Northcutt & McCoy, 2004) and calculated as the difference between the previous two columns.

Table 3
Pareto analysis—ASO school sample

Affinity pair relationship		Frequency sorted (descending)	Cumulative Frequency[a]	Cumulative percent[b] (relation)	Cumulative percent[c] (frequency)	Power[d]
1	Con ← Ap	49	49	1.1	2.0	0.9
2	Ss ← Ap	48	97	2.2	3.9	1.7
3	Opt ← Ap	47	144	3.3	5.8	2.5
4	Hp ← Ap	47	191	4.4	7.7	3.3
5	Lg ← Ss	46	237	5.6	9.5	4.0
6	Ss → Res	43	280	6.7	11.3	4.6
7	Mot ← Ap	43	323	7.8	13.0	5.2
8	Hp ← Mot	42	365	8.9	14.7	5.8
9	Mot ← Ss	42	407	10.0	16.4	6.4
10	Opt → Per	42	449	11.1	18.1	7.0
11	Lg ← Per	42	491	12.2	19.8	7.6
12	Hp ← Ps	41	532	13.3	21.4	8.1
13	Lg ← Opt	40	572	14.4	23.0	8.6
14	Hp ← Ss	40	612	15.6	24.7	9.1
15	Ss ← Con	38	650	16.7	26.2	9.5
16	Opt ← Ss	37	687	17.8	27.7	9.9
17	Opt → Con	36	723	18.9	29.1	10.2
18	Ap → Per	35	758	20.0	30.5	10.5
19	Mot ← Con	35	793	21.1	32.0	10.8
20	Mot → Per	35	828	22.2	33.4	11.1
21	Opt → Res	34	862	23.3	34.7	11.4
22	Lg ← Ap	34	896	24.4	36.1	11.7
23	Con ← Per	34	930	25.6	37.5	11.9
24	Mot ← Ps	33	963	26.7	38.8	12.1
25	Ss ← Ps	33	996	27.8	40.1	12.4
26	Hp ← Con	33	1029	28.9	41.5	12.6
27	Opt ← Hp	33	1062	30.0	42.8	12.8
28	Ss → Per	32	1094	31.1	44.1	13.0
29	Ps ← Ap	32	1126	32.2	45.4	13.1
30	Lg ← Hp	31	1157	33.3	46.6	13.3
31	Mot → 6	31	1188	34.4	47.9	13.4
32	Res ← Ps	31	1219	35.6	49.1	13.6
33	Opt → Mot	30	1249	36.7	50.3	13.7
34	Res ← 9	30	1279	37.8	51.5	13.8
35	Ap ← Per	30	1309	38.9	52.7	13.9
36	Hp ← Res	30	1339	40.0	53.9	13.9
37	Opt ← Ps	30	1369	41.1	55.2	14.0
38	Ps ← Per	29	1398	42.2	56.3	14.1
39	Con ← Ps	28	1426	43.3	57.5	14.1
40	Hp → Per	28	1454	44.4	58.6	14.1
41	Lg ← Con	28	1482	45.6	59.7	14.2
42	Ss ← Per	28	1510	46.7	60.8	14.2
43	Con → Ps	28	1538	47.8	62.0	14.2
44	Lg → Con	27	1565	48.9	63.1	14.2
45	Res → Con	27	1592	50.0	64.1	14.1
46	Opt → Ss	27	1619	51.1	65.2	14.1
47	Mot → Con	27	1646	52.2	66.3	14.1
48	Lg ← Mot	26	1672	53.3	67.4	14.0
49	Hp ← Per	26	1698	54.4	68.4	14.0
50	Opt ← Mot	26	1724	55.6	69.5	13.9
51	Opt → Hp	25	1749	56.7	70.5	13.8

Table 3 (*continued*)

Affinity pair relationship		Frequency sorted (descending)	Cumulative Frequency[a]	Cumulative percent[b] (relation)	Cumulative percent[c] (frequency)	Power[d]
52	Opt → Ps	25	1774	57.8	71.5	13.7
53	Con → Per	25	1799	58.9	72.5	13.6
54	Lg ← Ps	25	1824	60.0	73.5	13.5
55	Ps → Per	25	1849	61.1	74.5	13.4
56	Mot ← Per	23	1872	62.2	75.4	13.2
57	Res ← Per	23	1895	63.3	76.3	13.0
58	Ss → Ps	23	1918	64.4	77.3	12.8
59	Ss → Con	23	1941	65.6	78.2	12.6
60	Hp → Con	23	1964	66.7	79.1	12.5
61	Hp → Res	22	1986	67.8	80.0	12.2
62	Lg → Mot	22	2008	68.9	80.9	12.0
63	Lg → Ap	21	2029	70.0	81.7	11.7
64	Mot ← Res	20	2049	71.1	82.6	11.4
65	Hp → Mot	20	2069	72.2	83.4	11.1
66	Ps → Ap	19	2088	73.3	84.1	10.8
67	Lg ← Res	19	2107	74.4	84.9	10.4
68	Res → Ps	19	2126	75.6	85.7	10.1
69	Res → Per	19	2145	76.7	86.4	9.8
70	Mot → Ss	19	2164	77.8	87.2	9.4
71	Opt ← Res	18	2182	78.9	87.9	9.0
72	Lg → Ps	18	2200	80.0	88.6	8.6
73	Mot → Ps	18	2218	81.1	89.4	8.3
74	Hp → Ps	18	2236	82.2	90.1	7.9
75	Opt ← Con	18	2254	83.3	90.8	7.5
76	Ss → Ap	17	2271	84.4	91.5	7.1
77	Mot → Ap	17	2288	85.6	92.2	6.6
78	Opt ← Per	17	2305	86.7	92.9	6.2
79	Ss ← Res	17	2322	87.8	93.6	5.8
80	Res ← Con	16	2338	88.9	94.2	5.3
81	Res → Ap	16	2354	90.0	94.8	4.8
82	Con → Ap	16	2370	91.1	95.5	4.4
83	Lg → Res	16	2386	92.2	96.1	3.9
84	Opt → Ap	16	2402	93.3	96.8	3.4
85	Lg → Per	15	2417	94.4	97.4	2.9
86	Lg → Hp	15	2432	95.6	98.0	2.4
87	Hp → Ss	15	2447	96.7	98.6	1.9
88	Hp → Ap	13	2460	97.8	99.1	1.3
89	Lg → Ss	12	2472	98.9	99.6	0.7
90	Lg → Opt	10	2482	100.0	100.0	0.0

[a] The running total of votes for each affinity pair.
[b] Based on the number of possible relationships (90), each relationship represents 1/90 or 1.1% of the total.
[c] Cumulative percentage based on the percentage of the number of votes cast (4989).
[d] Index of the degree of optimisation of the system (Northcutt & McCoy, 2004) and calculated as the difference between the previous two columns.

Table 4
Conflict analysis—TSO/BSO school sample

Affinity pair	Frequency	Use in systems influence diagram
Lg → Ap	23	
Lg ← Ap	30	✓
Lg → Per	27	
Lg ← Per	27	
Opt → Hp	34	✓
Opt ← Hp	28	
Opt → Mot	32	✓
Opt ← Mot	28	
Opt → Ss	24	
Opt ← Ss	32	✓
Opt → Ps	33	✓
Opt ← Ps	23	
Opt → Per	33	✓
Opt ← Per	25	
Hp → Res	33	✓
Hp ← Res	23	
Hp → Per	28	✓
Hp ← Per	27	
Mot → Res	29	✓
Mot ← Res	28	
Mot → Per	28	
Mot ← Per	32	✓
Ss → Ps	23	
Ss ← Ps	31	✓
Ss → Ap	24	
Ss ← Ap	29	✓
Ss → Per	30	✓
Ss ← Per	25	
Res → Con	28	✓
Res ← Con	24	
Con → Per	28	
Con ← Per	29	✓
Ap → Per	37	✓
Ap ← Per	27	

Table 5
Conflict analysis—ASO school sample

Affinity pair	Frequency	Use in systems influence diagram
Lg → Mot	22	
Lg ← Mot	26	✓
Lg → Con	27	
Lg ← Con	28	✓
Opt → Hp	25	
Opt ← Hp	33	✓
Opt → Mot	30	✓
Opt ← Mot	26	
Opt → Ss	27	
Opt ← Ss	37	✓
Opt → Ps	25	
Opt ← Ps	37	✓
Hp → Res	22	
Hp ← Res	30	✓
Hp → Con	23	
Hp ← Con	33	✓
Hp → Per	28	✓
Hp ← Per	26	
Mot → Con	27	
Mot ← Con	35	✓
Mot → Per	35	✓
Mot ← Per	23	
Ss → Con	23	
Ss ← Con	38	✓
Ss → Ps	23	
Ss ← Ps	33	✓
Ss → Per	32	✓
Ss ← Per	28	
Con → Ps	28	
Con ← Ps	28	
Con → Per	25	
Con ← Per	34	✓
Ps → Per	25	
Ps ← Per	29	✓
Ap → Per	35	✓
Ap ← Per	30	

Table 6
Inter-tabular relationship diagram—TSO/BSO school sample

	Lg	Opt	Hp	Mot	Ss	Res	Con	Ps	Ap	Per	OUT	IN	Δ
Lg		←	←	←	←	←	↑	←	←	←	1	8	−7
Opt	↑		↑	↑	←	↑	↑	↑	←	↑	7	2	5
Hp	↑	←		←	←	↑	←	←	←	↑	3	6	−3
Mot	↑	←	↑		←	↑	←	←	←	←	3	6	−3
Ss	↑	↑	↑	↑		↑	←	←	←	↑	6	3	3
Res	↑	←	←	←	←		↑	←	←	←	2	7	−5
Con	←	←	↑	↑	↑	←		←	←	←	3	6	−3
Ps	↑	←	↑	↑	↑	↑	↑		↑	←	7	2	5
Ap	↑	↑	↑	↑	↑	↑	↑	←		↑	8	1	7
Per	↑	←	←	↑	←	↑	↑	↑	←		5	4	1

Table 7
Inter-tabular relationship diagram—ASO school sample

	Lg	Opt	Hp	Mot	Ss	Res	Con	Ps	Ap	Per	OUT	IN	Δ
Lg		←	←	←	←	←	←	←	←	←	0	9	−8
Opt	↑		←	↑	←	↑	↑	←	←	↑	5	4	1
Hp	↑	↑		←	←	←	←	←	←	↑	3	6	−3
Mot	↑	←	↑		←	↑	←	←	←	↑	4	5	−1
Ss	↑	↑	↑	↑		↑	←	←	←	↑	6	3	3
Res	↑	←	↑	←	←		↑	←	←	←	3	6	−3
Con	↑	←	↑	↑	↑	←			←	←	4	4	0
Ps	↑	↑	↑	↑	↑	↑			←	←	6	2	4
Ap	↑	↑	↑	↑	↑	↑	↑	↑		↑	8	0	8
Per	↑	←	←	←	←	↑	↑	↑	←		4	5	−1

Table 8
Inter-tabular relationship diagram–descending frequency of delta—TSO/BSO school sample

	Lg	Opt	Hp	Mot	Ss	Res	Con	Ps	Ap	Per	OUT	IN	Δ	Position in system
Ap	↑	↑	↑	↑	↑	↑	↑	←		↑	8	1	7	Primary driver
Opt	↑		↑	↑	←	↑	↑	↑	←	↑	7	2	5	Secondary driver
Ps	↑	←	↑	↑	↑	↑	↑		↑	←	7	2	5	Secondary driver
Ss	↑	↑	↑	↑		↑	←	←	←	↑	6	3	3	Secondary driver
Per	↑	←	←	↑	←	↑	↑	↑	←		5	4	1	Secondary driver
Hp	↑	←		←	←	↑	←	←	←	↑	3	6	−3	Secondary outcome
Mot	↑	←	↑		←	↑	←	←	←	←	3	6	−3	Secondary outcome
Con	←	←	↑	↑	↑	←		←	←	←	3	6	−3	Secondary outcome
Res	↑	←	←	←	←		↑	←	←	←	2	7	−5	Secondary outcome
Lg		←	←	←	←	←	↑	←	←	←	1	8	−7	Primary outcome

Table 9
Inter-tabular relationship diagram—descending frequency of delta—ASO school sample

	Lg	Opt	Hp	Mot	Ss	Res	Con	Ps	Ap	Per	OUT	IN	Δ	Position in system
Ap	↑	↑	↑	↑	↑	↑	↑	↑		↑	8	0	8	Primary driver
Ps	↑	↑	↑	↑	↑	↑			←	←	6	2	4	Secondary driver
Ss	↑	↑	↑	↑		↑	←	←	←	↑	6	3	3	Secondary driver
Opt	↑		←	↑	←	↑	↑	←	←	↑	5	4	1	Secondary driver
Con	↑	←	↑	↑	↑	←			←	←	4	4	0	Pivot
Mot	↑	←	↑		←	↑	←	←	←	↑	4	5	−1	Secondary outcome
Per	↑	←	←	←	←	↑	↑	↑	←		4	5	−1	Secondary outcome
Hp	↑	↑		←	←	←	←	←	←	↑	3	6	−3	Secondary outcome
Res	↑	←	↑	←	←		↑	←	←	←	3	6	−3	Secondary outcome
Lg		←	←	←	←	←	←	←	←	←	0	9	−9	Primary outcome

Table 10
Elimination of redundant links—TSO/BSO school sample

Link under investigation	Action taken	Rationale
Step 1: Investigation of forward links from high to low delta value[a]		
9-1	Delete	Alternative path is present: 9-2-1
9-6	Delete	Alternative path is present: 9-4-6
9-7	Delete	Alternative path is present: 9-2-7
9-4	Delete	Alternative path is present: 9-10-4
9-3	Delete	Alternative path is present: 9-5-3
9-10	Delete	Alternative path is present: 9-2-10
9-5	Delete	Alternative path is present: 9-2-8-5
9-8	None	Recursive link
9-2	Retain	No other path available, direct link
2-1	Delete	Alternative path is present: 2-6-1
2-6	Delete	Alternative path is present: 2-4-6
2-7	Delete	Alternative path is present: 2-8-7
2-4	Delete	Alternative path is present: 2-10-4
2-3	Delete	Alternative path is present: 2-8-3
2-10	Delete	Alternative path is present: 2-8-5-10
2-5	None	Recursive link
2-8	Retain	No other path available, direct link
8-1	Delete	Alternative path is present: 8-6-1
8-6	Delete	Alternative path is present: 8-4-6
8-7	Delete	Alternative path is present: 8-5-10-7
8-4	Delete	Alternative path is present: 8-5-4
8-3	Delete	Alternative path is present: 8-5-3
8-10	None	Recursive link
8-5	Retain	No other path available, direct link
5-1	Delete	Alternative path is present: 5-3-1
5-6	Delete	Alternative path is present: 5-3-6
5-7	None	Recursive link
5-4	Delete	Alternative path is present: 5-10-4
5-3	Retain	No alternative path available
5-10	Retain	No alternative path available
10-1	None	No link exists
10-6	Delete	Alternative path is present: 10-4-6
10-7	Retain	No alternative path available
10-4	Retain	No alternative path available
10-3	None	Recursive link
3-1	Delete	Alternative path is present: 3-6-1
3-6	Retain	No alternative path available
3-7	None	Recursive link
3-4	None	Recursive link
4-1	Delete	Alternative path is present: 4-6-1
4-6	Retain	No alternative path available
4-7	None	Recursive link
7-1	None	Recursive link
7-6	None	Recursive link
6-1	Retain	No alternative path available
Step 2: Investigation of recursive links from low to high delta value[b]		
1-7	Retain	No alternative path available
6-7	Delete	Alternative path is present: 6-1-7
7-5	Delete	Alternative path is present: 7-10-8-5

(*continued on next page*)

Table 10 (*continued*)

Link under investigation	Action taken	Rationale
7-3	Delete	Alternative path is present: 7-4-3
7-4	Retain	No alternative path is available
4-3	Retain	No alternative path is available
3-10	Retain	No alternative path is available
10-8	Retain	No alternative path is available
5-2	Delete	Alternative path is present: 5-10-8-9-2
8-9	Retain	No alternative path is available
10-4	Delete	Alternative path is present: 10-7-4
5-3	Delete	Alternative path is present: 5-10-7-4-3
4-6	Delete	Alternative path is present: 4-3-6

Conflict link	Action taken	Rationale
Step 3: Reconciling conflicts from pareto analysis ignored in inter-tabular relationship diagram[c]		
$1 \rightarrow 9$	None	Link already present: 1-7-4-3-10-8-9
$1 \rightarrow 10$	None	Link already present: 1-7-4-3-10
$1 \leftarrow 10$	None	Link already present: 10-7-4-3-6-1
$2 \leftarrow 3$	None	Link already present: 3-10-8-9-2
$2 \leftarrow 4$	None	Link already present: 4-3-10-8-9-2
$2 \rightarrow 5$	None	Link already present: 2-8-5
$2 \leftarrow 8$	None	Link already present: 8-9-2
$2 \leftarrow 10$	None	Link already present: 10-8-9-2
$3 \leftarrow 6$	None	Link already present: 6-1-7-4-3
$3 \leftarrow 10$	None	Link already present: 10-7-4-3
$4 \leftarrow 6$	None	Link already present: 6-1-7-4
$4 \rightarrow 10$	None	Link already present: 4-3-10
$5 \rightarrow 8$	None	Link already present: 5-10-8
$5 \rightarrow 9$	None	Link already present: 5-10-8-9
$5 \leftarrow 10$	None	Link already present: 10-8-5
$6 \leftarrow 7$	None	Link already present: 7-4-3-6
$7 \rightarrow 10$	None	Link already present: 7-4-3-10
$9 \leftarrow 10$	None	Link already present: 10-8-9

[a] Forward links are inspected and recursive links are ignored, the alternative path may not involve a recursive link.

[b] Recursive links are inspected for alternative paths and the alternative path may involve links in any direction.

[c] Conflicts from the Pareto analysis that were ignored in the inter-tabular relationship diagram are now added if they are not yet present in the systems influence diagram.

Table 11
Elimination of redundant links—ASO school sample

Link under investigation	Action taken	Rationale
Step 1: Investigation of forward links from high to low delta value[a]		
9-1	Delete	Alternative path is present: 9-3-1
9-6	Delete	Alternative path is present: 9-10-6
9-3	Delete	Alternative path is present: 9-4-3
9-10	Delete	Alternative path is present: 9-5-10
9-4	Delete	Alternative path is present: 9-8-4
9-7	Delete	Alternative path is present: 9-2-7
9-2	Delete	Alternative path is present: 9-8-2
9-5	Delete	Alternative path is present: 9-8-5
9-8	Retain	Direct link, alternative path not possible
8-1	Delete	Alternative path is present: 8-3-1
8-6	Delete	Alternative path is present: 8-2-6
8-3	Delete	Alternative path is present: 8-4-3
8-10	Retain	Recursive link
8-4	Delete	Delete
8-7	No action	No link
8-2	Delete	Alternative path is present: 8-5-2
8-5	Retain	Direct link, alternative path not possible
5-1	Delete	Alternative path is present: 5-3-1
5-6	Delete	Alternative path is present: 5-4-6
5-3	Delete	Alternative path is present: 5-4-3
5-10	Delete	Alternative path is present: 5-2-10
5-4	Delete	Alternative path is present: 5-2-4
5-7	Retain	Recursive link
5-2	Retain	Direct link, alternative path not possible
2-1	Delete	Alternative path is present: 2-4-3-1
2-6	Delete	Alternative path is present: 2-4-6
2-3	Retain	Recursive link
2-10	Delete	Alternative path is present: 2-4-10
2-4	Delete	Alternative path is present: 2-7-4
2-7	Retain	Direct link, alternative path not possible
7-1	Delete	Alternative path is present: 7-3-1
7-6	Retain	Recursive link
7-3	Delete	Alternative path is present: 7-4-3
7-10	Retain	Recursive link
7-4	Retain	Direct link, alternative path not possible
4-1	Delete	Alternative path is present: 4-3-1
4-6	Delete	Alternative path is present: 4-10-6
4-3	Retain	Direct link, alternative path not possible
4-10	Retain	Alternative path involves a recursive link
10-1	Delete	Alternative path is present: 10-6-1
10-6	Retain	Direct link, alternative path not possible
10-3	Retain	Recursive link
3-1	Retain	Direct link, alternative path not possible
3-6	Retain	Recursive link
6-1	Retain	Direct link, alternative path not possible
Step 2: Investigation of recursive links from low to high delta value[b]		
6-7	Delete	Alternative path is present: 6-3-2-7
3-2	Delete	Alternative path is present: 3-10-8-5-2
3-10	Retain	Direct link, alternative path not possible

(*continued on next page*)

Table 11 (*continued*)

Link under investigation	Action taken	Rationale
10-8	Retain	Direct link, alternative path not possible
10-7	Delete	Alternative path is present: 10-8-5-2-7
7-5	Delete	Alternative path is present: 7-4-10-8-5
4-3	Delete	Alternative path is present: 4-10-6-3
6-1	Delete	Alternative path is present: 6-3-1
Conflict link	**Action taken**	**Rationale**
Step 3: Reconciling conflicts from pareto analysis ignored in inter-tabular relationship diagram[c]		
1 → 4	Add	Not present in the systems influence diagram
1 → 7	None	Link present: 1-4-10-8-5-2-7
2 → 3	None	Link present: 2-7-4-10-6-3
2 ← 4	None	Link present: 4-10-8-5-2
2 → 5	None	Link present: 2-7-4-10-8-5
2 → 8	None	Link present: 2-7-4-10-8
3 → 6	None	Link present: 3-10-6
3 → 7	None	Link present: 3-10-8-5-2-7
3 ← 10	None	Link present: 3-10
3 ← 10	Delete	Alternative path possible: 3-1-4-10
4 → 7	None	Link present: 4-10-8-5-2-7
4 ← 10	None	Link present: 10-8-5-2-7-4
5 → 7	None	Link present: 5-2-7
5 → 8	None	Link present: 5-2-7-4-10-8
5 ← 10	None	Link present: 10-8-5
7 → 8	None	Link present: 7-4-10-8
7 ← 8	None	Link present: 8-5-2-7
7 → 10	None	Link present: 7-4-10
8 → 10	None	Link present: 8-5-2-7-4-10
9 → 10	None	Link present: 9-8-5-2-7-4-10

[a] Forward links are inspected and recursive links are ignored, the alternative path may not involve a recursive link.

[b] Recursive links are inspected for alternative paths and the alternative path may involve links in any direction.

[c] Conflicts from the Pareto analysis that were ignored in the inter-tabular relationship diagram are now added if they are not yet present in the SID.

Table 12
Comparison of similarity in the mental models of the TSO/BSO and ASO samples

Criteria	Agreement
Same primary driver	1
Same primary outcome	1
Different pivot	0
Proportion of similar secondary drivers	.75
Proportion of similar secondary outcomes	.75
Similarity score (SS)	.70

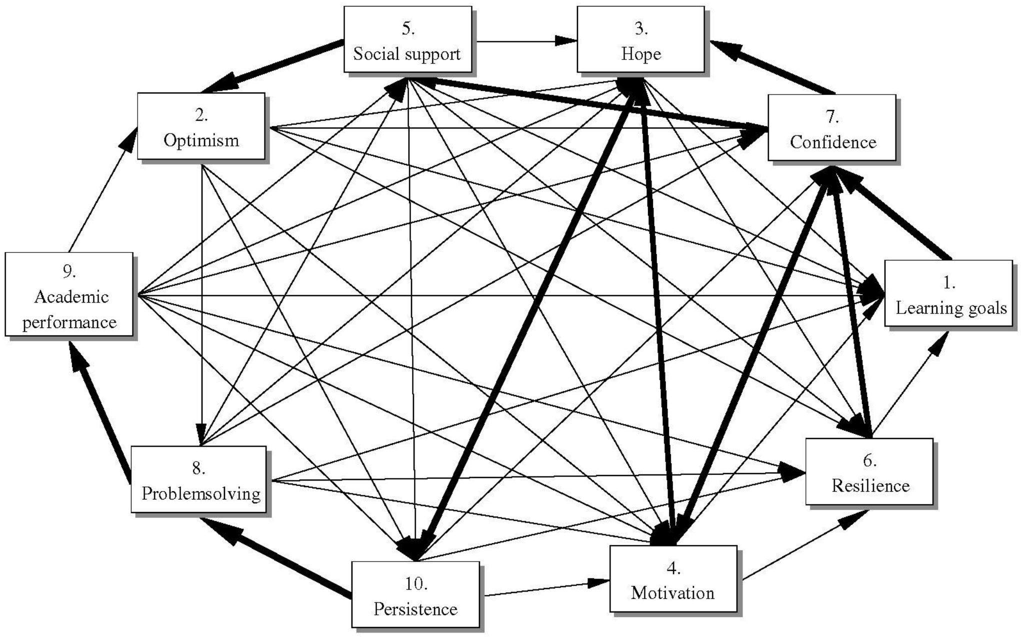

Fig. 1. Cluttered systems influence diagram—TSO/BSO school sample.

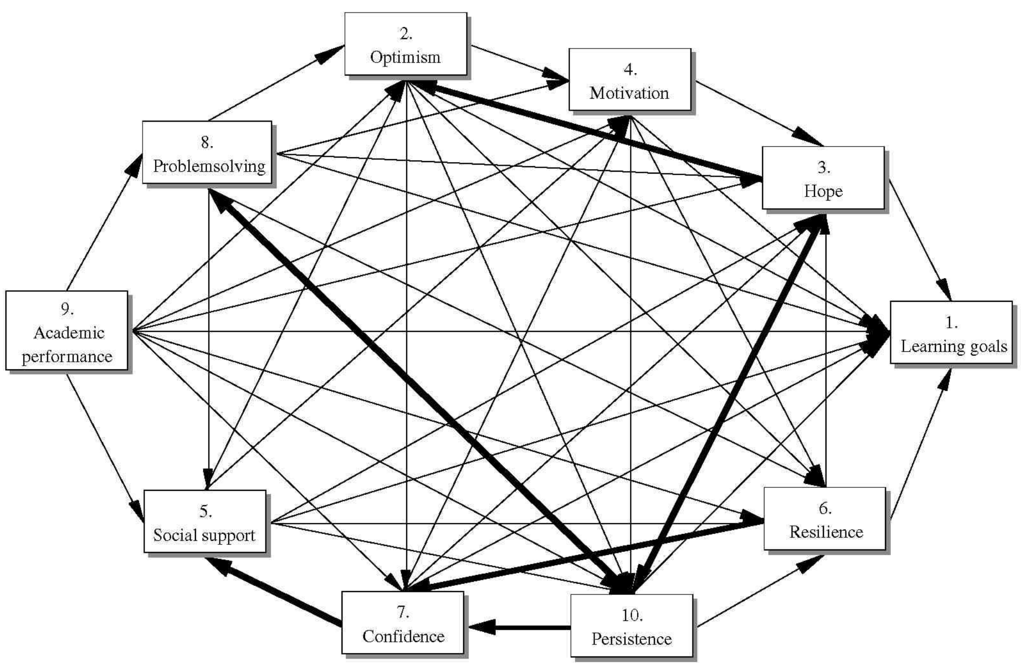

Fig. 2. Cluttered systems influence diagram—ASO school sample.

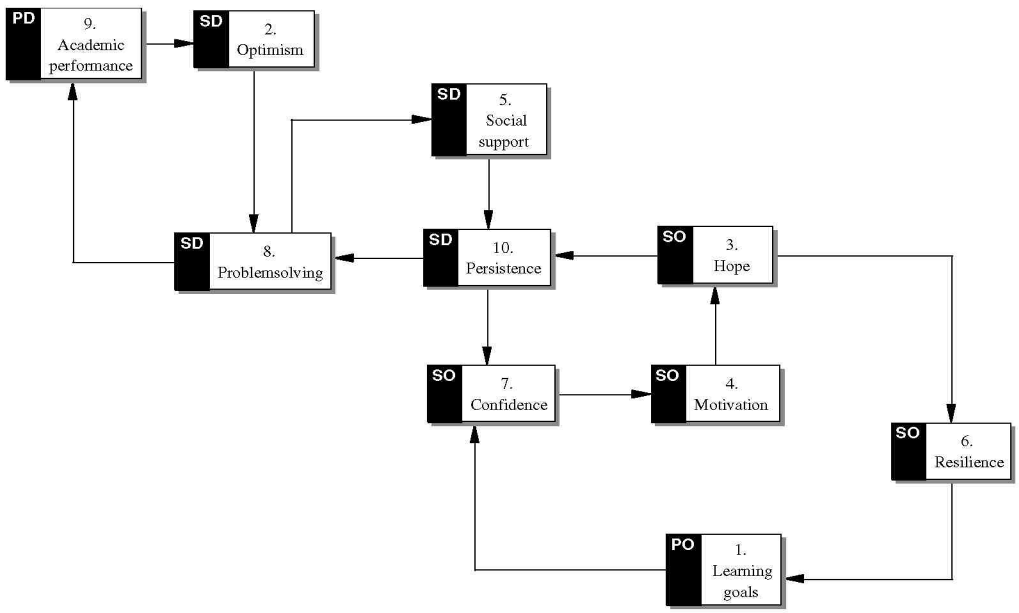

Fig. 3. Clean systems influence diagram—TSO/BSO school sample.

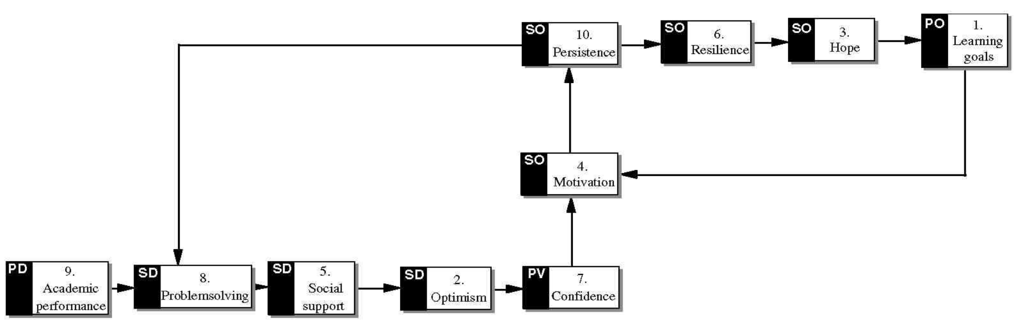

Fig. 4. Clean systems influence diagram—ASO school sample.