The enduring relevance of the Conceptual Mediation Program (CMP).

A meta-study by Potvin et al. (2020) of models of conceptual change stands as an extensive though troubling contribution to our understanding of the extent of science education theory and practice. What is troubling is the author's consensus view that there had been disappointingly little progress in terms of effective and practical pedagogical recommendations for teachers to implementing in classrooms. What is also evident from this review, however, is that there has been an almost total dominance in the research by epistemological perspectives and that little or no attention has been paid to the psychological underpinnings of student's intuitive beliefs and the published pedagogies that resolve these. Of the 86 perspectives described and evaluated there has been only one major contribution, referenced as Dawson (2014), that has focussed on the psychological causes of learning difficulties found in our schools and that being the Conceptual Mediation Program (CMP). In the colourful graphics provided Potvin et al. we find it ranked very lowly on all variables studied, and from the brief summary comments one would scarcely look at it twice. However, I propose a critical distinction, CMP it is not a model of conceptual change, it is a pragmatic and effective pedagogy based on a recently understood mode of learning, that I have called mediational learning (Lyndon, 2000). To highlight these concerns, it will be useful to reconsider some of the perspectives offered in various formative contributions to this field of research such as Hewson and Hewson (1984), Duit &Treagust (2003), Potvin (2013), diSessa (2014), Potvin (2017).

- Conceptual conflict has long been recognized as a factor that could facilitate student learning. Due, however, to the lack of a convincing explanation of why it occurs, and how it can be resolved, it has seldom been used in instructional design. … The idea that conflict in a student's mind is likely to lead to learning is not new. As Nussbaum and Novick (1982) point out, Dewey (1910), Festinger (1957), Piaget (1964) and Berlyne (1965) all used it, albeit in different contexts. …. Two terms have, however, been used - "cognitive conflict" and "conceptual conflict." In this article, we use the latter term because we believe that it is profitable to consider learning from an epistemological point of view, and that the term "conceptual conflict" reflects this point of view more adequately than does "cognitive conflict." In support of this belief we argue, following Strike (1983), that learning a new idea is a rational enterprise which requires the learner to relate the new idea to his or her current concepts. ***Thus, in examining the role that conflict plays in learning, we have chosen to turn to epistemology rather than psychology***. (emphasis added)   (Hewson and Hewson, 1984)

- The state of theory building on conceptual change has become more and more sophisticated and the teaching and learning strategies developed have become more and more complex the past 25 years. These developments are, of course, necessary in order to address the complex phenomena of teaching and learning (science) more and more adequately. However, the gap between what is necessary from the researcher perspective and what may be set into practice by 'normal' teachers has increased more and more also. In other words, there is the paradox that in order to adequately address teaching and learning processes research alienates the teachers and hence widens the 'theory-practice' gap.   (Duit &Treagust, 2003)

- Misconceptions were phenomenological (diSessa, 2004), social (Perret-Clermont, 1996), experiential, or based on core intuitions (Brown, 1993), automatic mental habits (Fischbein, 1987), intuitive rules (Stavy & Tirosh, 2000), and frameworks (Vosniadou & Brewer, 1992), etc. The multiplicity of their origins, added to the multiplicity of their forms, from one culture to another (Loubaki, Potvin, & Vazquez-Abad, 2012; Stavy et al., 2006), from one learner to another, made the task of diagnosing all the possible conceptions ecologically unviable, and the possibility of intervening adequately on all of them even more unviable.   (Potvin, 2013)

- Many academic disciplines have examined conceptual change, resulting in a wide range of perspectives that can be hard to reconcile. There are no widely accepted, well-articulated and tested theories. Instead, the field consists of multiple perspectives that combine many common sense and theoretical ideas in kaleidoscopic fashion. … Posner et al. maintained that their framework was epistemological and did not reflect psychological reality or provide a model for instruction. Still, many science educators organized instruction around the framework (e.g., Smith, Maclin, Grosslight, & Davis, 1997). Some even introduced students explicitly to the framework (Hewson & Hennessey, 1992)
                                                                          (diSessa, 2014)

- Consistent with this idea of "reconstruction," much research conducted during the '90s and early 2000s concentrated on the cognitive resources that constrain such "reconstructions" when initial conceptions interfere. Such resources were sometimes called p-prims (DiSessa, 1993), intuitive rules (Stavy & Tirosh, 2000), core intuitions (Brown, 1993), ontological frameworks (Vosniadou, 1994), heuristics (Gigerenzer & Todd, 1999; Maeyer & Talanquer, 2013), etc…   (Potvin,2017)

There are then two major and closely related issues presented by these quotes; firstly, the nature of the theoretical underpinnings of the main contributors to this research and secondly the

consensus view that there had been disappointingly little or no progress in pedagogy. The CMP directly addresses these major concerns and provides both a theoretical and pedagogical resolution.

From simplicity to complexity

The development of a remedial method that came to be known as Old Way/New Way (OW/NW) was inspired by the most fundamental of epistemological considerations such as: what is knowledge, who does the learning and how do we change what we already know i.e., how do we change our mind? The realization that student's errors represented a problem of knowledge rather than its absence was an epistemological epiphany which led me to consider what psychological theory had to offer in resolving this conundrum. I could no longer expect that a student would respond positively to being shown or told they were wrong when they knew they were right! It became clear that from a behaviourist point of view that any attempt to offer a student a correct alternative was in effect simply providing an opportunity for them to learn a new response to an old stimulus condition. If that was the case, I reasoned, I should offer them the chance to practice the discrimination itself. The outcome of this simple change of perspective, i.e., that students were never simply wrong when they misspelled a word or used an ineffective algorithm in arithmetical tasks, was behaviourally and affectively significant and led to the development of this novel remedial method. Working with many students and their teachers over the next few years provided an opportunity to observe a number of consistent phenomena that begged for a more complex theoretical framework than was afforded by the initial discrimination learning perspective; this need was eventually met by Associative Interference Theory (Underwood, 1966). However, it was necessary to reformulate a critical aspect of this theory, in order to show that this vast body of research had direct relevance to learning in general and not merely to clinical verbal learning.

- Although a frequently used experimental paradigm, AB-ABr has been considered to be of analytic interest only. Underwood has stated that there are very few examples of this paradigm in the real world (Underwood, 1966, p. 507). However, the assumption that examples of the powerfully inhibiting AB-ABr paradigm rarely occur in the real world merits careful reconsideration.   (Lyndon, 2000 p53).

- The AB-AD paradigm is the traditional negative transfer paradigm used to study the effect on recall of changes in the response items being used. A list of say twelve word pairs are learnt to a set criterion of recallability and this is then followed by the learning of a second list of word pairs, also to criterion. All stimulus items (A) of the second list of paired associates (AD) are the same as for the first list (AB). None of the first list response items (B) are included in the second list response items (D). Subjects are then tested immediately for recall of the AD list. An example of this would be:

• A	• B	• A	• D
• dog	• iron	• dog	• falcon
• cat	• steel	• cat	• hawk
• rat	• gold	• rat	• eagle

- An important variation on the AB-AD paradigm is the AB-ABr paradigm. This experimental structure varies from the AB-AD form in that only first list response items are used during re-learning of the second list. This involves a re-pairing of first list stimulus and response items. An example of the AB-ABr paradigm is:

• A	• B	• A	• Br
• dog	• iron	• dog	• gold
• cat	• steel	• cat	• iron
• rat	• gold	• rat	• steel

- We know from previous research (Underwood, 1966) that the degree of negative transfer and proactive inhibition, occurring under the AB-ABr paradigm is significantly greater than that occurring under the AB-AD condition. The paradigms produce these differential effects on transfer due to the fact that under the AB-AD condition there is only one identifiable inhibitory factor, that of forward association, whereas under the AB-ABr condition we can identify two inhibitory factors. These are the factors of forward and of backward association. **However, …, it is the existence of three positive transfer factors under the AB-ABr condition, compared to only one positive transfer factor under AB-AD, that is of the greatest significance in understanding the process of change.** (emphasis added) (Lyndon, 2000 p51f)

These critical positive transfer factors which enhance learning are *stimulus discrimination, response discrimination,* and *response practice.* These positive transfer factors are facilitated by a subject's conscious attention to and progressive differentiation of all three experiential conditions.

When an individual seeks to change already acquired habits, skills, or concepts the approach to such change is by necessity a mediational process that places special demands on the learner. The term mediation is here used to mean that an individual consciously attempts to bring about a reconciliation of his or her conflicting habits, skills or concepts. Associative Interference theory describes and explains the critical role in verbal learning tasks involving conflict of psychological phenomena such as proactive inhibition, retroactive inhibition, accelerated forgetting, spontaneous recovery and unlearning. Proactive inhibition is best understood as the effect of conflicting prior knowledge on new learning. Despite a person's best efforts to change, prior

habits, skills or concepts quickly regain control over an individual's performance. Accelerated forgetting is a fundamental characteristic of human memory. It is now understood that proactive inhibition causes the accelerated forgetting of any new but conflicting habit, skill or concept, despite the practice of the newly learned habit, skill or concept. It is an essential aspect of the perceptual process that is activated whenever there is conflict between what is already known and what is being taught where mediation is not consciously undertaken by the learner. The conscious and progressive differentiation between the old and new responses is a necessary condition for the redirection of the accelerated forgetting effect.

A study funded by the Australian National Training Authority investigated the relative effectiveness of skill correction in a group of vocational education students using OW/NW compared with that obtained by conventional methods of remediation (Baxter et al., 1997). The results illustrate that where students and their teachers used conventional teaching methods in an attempt to correct pre-existing skills retention of the new skill, one week after remediation, was only 20 per cent. This result is directly predicted by the research on the effects on re-learning of proactive inhibition. The students experienced accelerated forgetting of the new skill, that is, they showed an 80 per cent loss in retention of the new skill. Conversely the group of students who used the OW/NW method demonstrated that they had only been subject to a normal rate of forgetting of the new skill, that is approximately 20 per cent loss of retention. This too is in line with the research presented on normal rates of forgetting. Furthermore, those students who had mediated between their conflicting skills were then able to progress to skill mastery over the following two weeks without any additional teacher instruction.

Numerous other studies have reported similar positive outcomes through the use of mediational learning pedagogy; these have been in:

- Speech Pathology, Lyndon & Malcolm (1984) and see Lyndon (1995) for useful graphics on the use of this mediational methodology applied to spelling and language.
- the teaching of mathematics, Baxter, E. P., & Dole, S.L., (1990), Dole, S. (1991,1992,1999, 2003), Dole, S., Cooper, T.J., & Lyndon, H. (1997).
- Studies showing the effectiveness of mediational learning have also been published in the field of elite sports; Bannon, S., Rawlins, T. & Baker. K. (2001), Baker, K. & Tan, G. (2001), Koulianou, M. & Vosniadou, S. (2002), Hanin, Y., Korjus, T., Jouste, P., & Baxter, P. (2002), Cooke, G. (2003) and Hanin, Y., Malvela, M., & Hanina, M. (2004).
- Other studies have related to the effective application of mediational learning strategies within industry settings: Baxter, P. (1998), Weaver, G., Baxter, P. & Lyndon, E. H. (2000), Smallwood, T. (2000).

THE DEVELOPMENT OF CONCEPTUAL MEDIATION

If, as is claimed by some science educators, that students must become involved in major paradigm shifts to become scientists, or to even understand what it is to be one, then science educators are effectively involved in a major corrective undertaking. The Conceptual Change literature clearly announces that this has been the experience of science educators since systematic research began in the early nineteen seventies. This state of affairs has led to considerable theoretical speculation amongst science educators about probable causes, and has also brought about some development of improved teaching strategies. The need, however, for a viable theory and effective methodology for conceptual change is still evident. The revitalized perspective on the function and significance of proactive inhibition and the potential solution to the pragmatic problem of conceptual change, as explained in Lyndon (2000) will here be elaborated on within the context of the class-oriented approach of Rowell & Dawson (1985), whose research was predominantly based on Piaget's theoretical model of equilibration.

A fortuitous collaboration with Rowell and Dawson led to the implementation of a foundational study for the development of Conceptual Mediation (Rowell, Dawson & Lyndon, 1990). Rowell and Dawson were early contributors to the domain of Conceptual Change and were informed by the prevalent epistemological frameworks of Piaget, Kuhn, Lakatos and Musgrave, Toulmin and others publishing at that time.

> Due to the limited success of that approach, our next step (Rowell and Dawson 1985) was influenced by Lakatos and Musgrave's (1970)'s view that for theory change to take place in science, there must be a comprehensible, competing theory available before an earlier one can be discarded, and we proposed that, possibly, this might also apply at the psychological level. We took into account Kuhn's (1993) argument that in asking for conceptual change, the learner was most frequently being required to construct the strategic knowledge (i.e., the scientific theory) and the meta-strategic knowledge (knowing when the theory should be applied) at the same time. Our modified conflict strategy, which was introduced in a class-based experiment, and compared with a standard conflict approach, deliberately separated the introduction of strategic and meta-strategic knowledge … Results indicated that students in the two classes made about the same level of progress when the post-test was administered. However, in a delayed post-test (6 weeks later), the modified conflict group demonstrated a statistically significant higher level of stability in the progress made. Nevertheless, some students did not change their views, and we looked for further improvement eventually developing an approach which we named "conceptual mediation".
>
> (Dawson, 2014)

Adopting a mediational perspective meant that it was necessary for Rowell and Dawson to replace the epistemologically inspired informal and relatively unstructured co-operative debate strategy, with a more formal, psychologically inspired, mediational phase. This procedure being suggested

by the application of OW/NW within various everyday settings across all age ranges within schools. It had been established that this procedure was applicable even when a group of students shared the task of describing the progressive differentiation of a commonly held misconception with a preferred perspective. Although there are natural limitations to any group-learning process, it was observed that students using the mediational strategy displayed a strong interest in the performance of their peers. This social phenomenon had the effect of actually improving the attention of students to the subject under discussion by that group of peers.

For this study three teaching strategies were devised and randomly allocated with three non-streamed year seven classes at a local primary school meeting. Class A was taught the better theory, that object volume explains displacement, and followed this with co-operative debate of selected questions. Class C was taught the better theory, and followed this with the OW/NW strategy. Class B was given the OW/NW strategy only. The results of this study were significant in two main ways. Firstly, the replacement of the informal co-operative debate approach with a formal mediational strategy, directly tied to specific components of the students' preconceptions, led to a significant improvement in learning and the retention (some five weeks later) of the scientific concept. A second and important aspect of this study was the fact that the use of an OW/NW strategy without the initial teaching of a better theory was surprisingly ineffective. Only one student out of 16 had retained the new concept on retest following the five-week retention interval. Students in classes A and C, that had been presented the better theory, differed only in the strategy used to follow up the initial differentiation of the competing concepts. The co-operative debate class, class A, showed an overall 36 per cent retention of their new understanding of the relationship between object volume and displacement volume. Class C, which had mediated between their specific preconceptions and the new concept, following the presentation of a better theory, showed an overall 73 per cent retention of their new concept.

Retesting of the Year seven students occurred some five weeks after the intervention; this represented a most severe test of retention of any learning that may have occurred as no additional interaction with these constructs was offered by teaching staff. Like the vocational education students who had received conventional remediation, class A demonstrated accelerated rates of forgetting of the new concept. Although certain individuals had transferred to the new way (seven of 19 students from class A), the quasi-mediational nature of co-operative debate places this result within expectations. The results obtained by class C on retest, were consistent with those obtained by the vocational education students using the OW/NW method (Baxter et al., 1997). The results from both groups showed that accelerated forgetting had been successfully redirected by the inclusion of a mediational phase in the teaching strategies used. In class C, 11 out of 15, or 73 per cent, of the students, showed long-term retention of the new concept of volume. This illustrates that the group had only shown the degree of forgetting associated with

normal rates of forgetting, that is, the rate of forgetting of information which has been practised but is not in conflict with prior knowledge or experience. Taken together, the results of these studies support the claim that the use of a mediational learning strategy can control the phenomenon of accelerated forgetting normally associated with the learning of a conflicting activity or concept.

An important conclusion drawn from this study was that when teachers use a mediational strategy to facilitate learning, what must be elicited and then progressively re-elicited is the student's specific prior knowledge, not merely demonstrated and or explained examples of its application. In the case of class B there was no effective elicitation and re-elicitation of the students' prior understanding of volume. Despite numerous demonstrations of both conflicting and consonant events being presented and discussed with these students in a formalized mediational setting, there was no real opportunity for the students to sufficiently reflect on their own prior knowledge or on the new concept itself. This opportunity was provided to both class A and class C. These students received 25 minutes of detailed better theory presentation that provided a natural opportunity for the elicitation of their own understanding of object volume and its relationship to displacement volume. It was the failure of students in class B to retain the new way, compared to the success of students in class C, that highlights the distinction between OW/NW as a method for changing habits and skills, and its application to the more complex activity of conceptual change. The use, then, of conflicting exemplars by science teachers can be seen only as a necessary but not a sufficient condition for conceptual change.

CONCEPTUAL MEDIATION WITHIN A SCHOOL SETTING

A CMP to specifically address the learning needs of science students at a public secondary school was initiated in 1994 with the support of the Principal, Roger Henderson, and senior science teachers David Lloyd (1999) and David Wilkinson (1999). The CMP was later trialled in three secondary schools within the Australian Capital Territory, Canberra High, Lake Ginninderra High and Lanyon High School.

The combination of the meta-cognitive strategies underpinning the OW/NW method the whole of class approach to facilitating conceptual change arising from Rowell, Dawson and Lyndon's 1990 study were the foundational elements of the CMP. A key element was that the meta-cognitive strategies would form a public and transparent learning framework shared in a collaborative manner by teachers, students and parents. To make the task manageable for teachers it was designed to be introduced and applied on a whole of class basis as it was considered applicable to all student's irrespective of their learning needs. All students were provided with a Handbook describing the various psychological elements to CMP and the associated specific metacognitive skills recommended (Lyndon, 2008).

- By encouraging students to take an active role in sharing personal experiences and understandings, the program permits confirmation of significant pre-existing ideas and

the introduction of relevant new concepts dealing with the nature of learning, memory and performance. It is delivered by teachers and takes the equivalent of four lesson periods. Further time is taken as needed over the year to revise and consolidate the meta-cognitive strategies that are shared. Issues discussed with students in the first phase of the program include the nature of the learning experience, the relationship of attention and learning. different role and functions of recognition and recall memory, use of efficient learning strategies to improve recall memory, nature of forgetting and the role of creativity in the learning process. The second phase concentrates on the distinction between natural and accelerated rates of forgetting. introducing and demonstrating the existence of proactive inhibition and its role as a knowledge protection mechanism the use of the old way/new way method as an efficient strategy for controlling the effects of accelerated forgetting, becoming independent mediators of the natural process of conceptual change. Through sharing a common learning framework teacher and students become collaborators in change. Students are empowered to take control of and accelerate the natural process of change. (Lyndon,1995)

An independent evaluation of the influence on student learning of conceptual mediation was commissioned by the South Australian Department for Education Training and Employment late in 1998 and Yates, a psychologist from the University of South Australia, was appointed to undertake this review. His comprehensive studies investigated the general impact of conceptual mediation upon teachers and students' attitudes to learning and to schooling until the completion of the project.

Of the total of 177 students involved in the South Australian study in 1998, only 73 students from Years 8-10 had been taught mediational learning strategies. The students in the Yates study were evaluated using two questionnaires: (1) Student Perception of Difficult Subjects Scale and (2) Magill Personal Belief Questionnaire, which included one item that required students to provide a written response. A "probe" question was used to evaluate students' awareness of problem-solving strategies. The results of this relatively large cross-sectional study of all the students from Years 8 to 10 demonstrated that the project has, over time, an unanticipated and beneficial effect on student attitudes to learning and to school:

- We can interpret the current data as indicating that CMP is associated with highly desirable educational outcomes of benefit to young people striving to adjust to the demands of current schooling pressures. We submit that any educational procedure or curriculum innovation that can claim to be associated with positive motivational indices, reduced school hostility, and less malaise, has to be taken very seriously.

(Yates et al., 1999)

These significant results may be attributed to a combination of factors. Firstly, to the students' improved understanding of the collaborative nature of learning and secondly to the emphasis

that the teachers placed on eliciting and then mediating between the students' and the scientific language used in a new topic. Thirdly, to the confidence students acquire about how to control the learning process when they are confronted by conceptual conflict.

Yates undertook an evaluation of the early implementation of CMP at Canberra High and also found that:

- students who participated within classes taught using the CMP method scored more highly on (a) positive work dimension (means of 39.8 vs 37.4). The level of students who scored over the natural midpoint was 79% in the control group and 85% in the CMP group.

- There was no overall effect for either gender or year level, and the interaction effects were not significant. That is, the effect for CMP on positive attitudes applied equally well for both genders and across year levels.   (Yates and Lyndon, 2001)

Yates's most valuable contribution to the CMP team was his decision to undertake a comparative study of the school's year 12 public examination data between 1998 and 2001:

- In the present study we sought to use the Year 12 Senior Secondary Assessment Board, South Australia (SSABSA) results as one index of the effectiveness of CMP at the project school. As part of on-going program evaluation, the Year 12 summative data, as supplied to the school by SSABSA, were subject to analysis. Between 1998 and 2001 it was possible to track the results of 155 individuals who completed Year 12 topics at the school site and so obtained scores on the HEES measures. The term HEES refers to Higher Education Entry Scores, and hence these data represent a salient outcome measure of the high school years. (Note: SSABSA data exist in two forms, i.e., an achievement score and a HEES score, both expressed out of 20. The HEES index is a scaled score derived from the achievement score, which is used to generate TERs. Hence in this report only the HEES index was used.)

- Of the 155 students, it was found that 53 had participated with the school's CMP program within their studies at Years 11 and/or 12. The CMP procedures were taught to some entire classes as they participated in these 3 subjects (but not others) within their Year 11 and/or Year 12 studies. However, not all students participated within such classes, and so it became possible to contrast the scores of students who had, and those who had not, exposure to the CMP program within their two final high school years.

- It is noteworthy that CMP students outperformed their non-CMP peers and the state norms in seven subject areas: The Overall HEES for non-CMP students was 10.8 (n 102) for CMP students 13.7 (n 53) with an effect size of 1.04. The coefficient used is the Cohen *d*. The term effect size refers to a measure of the magnitude of a treatment effect. It does

not refer to statistical probability as such, and is independent of sample size. That is, an effect size of 1.0 represents a difference, between two groups in the order of one standard deviation. Within behavioural sciences research programs effect size of 0.5 are considered moderate to strong. Yates & Lyndon, (2002)

The CMP confronts teachers with an interesting and challenging period during which both they and their students accommodate to the reality of a least-effort principle associated with learning to change what one already knows. It comes as no surprise that, when the least effort possible to achieve relearning of inappropriate habits, skills or misconceptions is far greater than students may desire, a natural reluctance to undertake the activity is initially felt and expressed. However, mediation strategies appear to assist students in managing their competing ideas through addressing them at a crucial instructional moment. In that CMP encourages a student to reactivate old ideas and progressively differentiate them from the recently presented new ones; so the learning strategies it recommends are initially counter intuitive. However, the present data suggest that these counter-intuitive strategies can be effective and useful to students within the normal classroom experience.

Dawson has provided us with a concise summary of the general CMP procedure:

- Our actual teaching strategy thus became as follows: (1) Teachers and students were introduced to the theoretical ideas and the teaching approach to be used. The important thing for them to understand was that any problem experienced with adopting a changed idea is not always the fault of the learner; instead, it is a function of everyone's conservative brain. If a student finds a new idea difficult, it might be due to PI, not to inability or lack of effort, and this effect can be minimised by the current approach. (2) The teacher conducts a pre-test, or conducts a discussion, on the key concepts of a new topic to determine whether students already hold strong, non-scientific views on it (Note that correct answers do not necessarily mean the students have correct reasons for these—so the teacher has to be thoughtful when designing questions). Some knowledge of the literature is useful here as it has generally been found that students from different places and cultures tend to have similar, if unscientific, understandings in a number of areas. If many do have strong, non-scientific ideas, CM is appropriate at a class level. Where there are only a few learners with non-scientific, pre-existing views, normal sound teaching methods can be used, with CM being used to support the few individually. (3) If a high level of PI among many of the class is anticipated, then the CM steps are: (a) Identify the students' existing views. This might be done using a pencil–paper test, the interpretation of diagrams or by requiring responses with explanations, to demonstrations. Students record their responses—usually using a 'paper memory' (b) Teach the scientific view as an alternative, 'what if' view, remembering that the ability to recall new information relatively easily requires several repetitions of the new material.

So, this step requires learners to practise using the new view in a number of situations. (c) Formally examine some of the examples used in the pre-test, together with new ones, asking what the students' old view would say about the situation, and what the new view would say. Then, identify the differences between the two. This is a key step—learners must be actively involved in every part of this, with classroom discussion or debate being most valuable. After about five repetitions of this, preferably using new situations each time, the students should retain the new view as a possibility, and it should not be subject to accelerated forgetting. (d) Provide a range of examples with students practising only the new view in a range which extends its application.   Dawson (2014, p 394)

Additional data, not reported here, indicate other positive benefits to the students of the CMP including, advanced problem-solving skills and more positive attitude to study and their own education. (Yates and Lyndon, 2004). Taken together, the results of our decade long study give a picture of a lengthy but academically beneficial transition from old beliefs and practices about learning to more effective and overall, more efficient learning strategies.

The naturalization of consciousness

The CMP is a pluralist pedagogy in that it combines the insights of the philosophical work of Plato, Descartes, Kant, Hegel, and Herbart; the psychological theorizing and experimentation on learning and memory and the role of inhibition proposed by Underwood and many of his colleagues; the Piagetian inspired whole of class co-operative debate approach developed by Rowell & Dawson, and successfully enhanced by the adoption of a mediational phase into their method; the teaching expertise and collaborative insights of the projects science educators Lloyd and Wilkinson; and necessarily it accommodates the representational pluralism that is inherent in our students. CMP accommodates to this fact by encouraging a truly collaborative and mediational dialogue between student and teacher. It emphasises the epistemological truism that knowledge is the prerogative of the individual; it is not to be found in the written or spoken word nor in the 'manifold' of ongoing experience. Instead, as Kant in the *Critique* laboured to explain, it is to be found in the conformity of the world to the individual.

- It has hitherto been assumed that our cognition must conform to the objects; but all attempts to ascertain anything about these objects a priori, by means of conceptions, and thus to extend the range of our knowledge, have been rendered abortive by this assumption. Let us then make the experiment whether we may not be more successful in metaphysics, if we assume that the objects must conform to our cognition.

Kant (CPR, p110)

It is the individual who must form the intuitions and representations of their world, and to make critical judgements that constitute their formative beliefs. It is the innate capacity of our perceptual and reasoning functions that facilitate any individual's intellectual development. These representations and developing cognitions are thus necessarily subjective, and within any

society there is a natural tendency to demote these habits, cognitions, and understandings to the level of beliefs; to the individual concerned however, they are what are known. Societies' preference is for knowledge defined as justified true belief and so teachers are prone to be concerned with the errors their students present in spite of the best of teaching efforts and the additional practice of the correct perspective. Our program recognizes that educators have a room full of students with a plurality of alternative intuitively derived knowledge; we encourage them to share these intuitive views and to then collaboratively mediate with the current scientific perspectives.

We recall that Hewson and Hewson (1983) pursued a rationalist epistemological perspective on conceptual change despite being aware that conflict could facilitate learning. For them a convincing psychological explanation as to how and why conflict had this potential role in learning was unavailable. It could be argued that their concerns and influential theorizing majorly contributed to the epistemological orientation of future researchers into conceptual change. The CMP by adapting the perspective of the Associative Interference theorists and in reconsidering the role of the AB/ABr negative transfer paradigm were able to provide and answer to the Hewson's important question. When confronted by perceptual or cognitive conflict the brain enters a mental state that is felt by the individual as confusion with all its attendant feelings. There is however at that critical time the possibility of taking advantage of the phenomenon. At the very moment that a conflict is registered there are two possible outcomes. One is negative transfer, as there are two negative transfer factors at play. The other is positive transfer because as has been shown we find three positive transfer factors available to facilitate learning. Where students discriminate between the stimuli, the various possible responses and then practice the discrimination an optimal number of times the learning is retained. So, confusion is good; it is a signal that the brain is ready to change; the brain has evolved a means of changing itself. The brain that we are born with is, to use a familiar analogy, a remarkable biological computer, however unlike the artificially intelligent computers we have developed our naturally intelligent system is self-programming and is capable of self-correction and creativity. That evolved process is what we term consciousness. Mediational learning is only possible due to the combination of three of our unique capacities, consciousness, language and reasoning. One of the recent conclusions that has been reached regarding mediation leaning has led to what can be called the naturalization of consciousness. An outline of this radical proposition will be present.

Experience is the emergent property of unconscious neural processes; it is direct and without the mediation of any representation of that momentary experience! Representations in all their complexity are clearly understood to be formed post hoc. This suggests that the 'Hard Problem' of consciousness is based on a misconception, that being, that we have conscious or phenomenal experience (Chalmers, 1995) (Block, 1995). Experience with all the attendant qualia that entrail is by necessity a direct form of awareness but is by no means necessarily a conscious process. Awareness, or sentience, needs to be distinguished from consciousness! Neurological analysis of

consciousness has shown that it is best represented as a serial process in the brain whereas awareness has been identified as a parallel process, (Barrs, 2005). The two mental states are therefore distinct and measurably so. Research initiated by Libet et al, (1967) and elaborated by Soon et al, (2008) has conclusively shown that consciousness is after the fact, that the principal self is thus an unconscious self, with consciousness appearing some 200 plus msecs after the event! The role then for consciousness is that of providing an emergent mediational representational space through the constraint of sensory and semantic processes. A mechanism that is in essentially inhibitory in nature. What is inhibited is the ongoing stream of experience in preference for this emergent though transient representational space that permits the resolution of conflicts, the synthesis of new ideas or to resequencing the prevalence of old ones.

The naturalization of consciousness has been a prevalent topic of psychological, neurological and philosophical debate for the some little while and it is of particular interest that the CMP has as a foundational thesis that the conscious mediation of conflicting representations facilitates learning for all.

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