Gifted Students Who Have Academic Learning Difficulties: Analytical Sequential Processing Problems?

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The dual exceptionalities of giftedness and underachievement manifest in a range of ways from the earliest stages of formal education. One group comprises gifted students who also have learning difficulties (Brody & Mills, 1997; Fetzer, 2000; Hishinuma & Tadaki, 1996; Rivera, Murdock, & Sexton, 1995). These students display a learning capacity that is characteristic of students who are gifted, in parallel with a specific learning disability in areas of academic performance such as literacy and mathematics.

For primary-age gifted students, the specific literacy learning disability is shown in areas such as reading, writing and spelling. Its cause is a difficulty using analytic information processing strategies that influenced their phonemic awareness knowledge and alphanumeric symbolic coding ability (Munro, 2005, 2002a, 2002b). Three types of literacy learning profiles have been identified. All shared the analytic sequential processing difficulty. The ways in which it influenced the literacy abilities depended on the domain/s in which the students were gifted.

A second cohort comprises those students who, in the middle to later years at their secondary education, display both gifted knowledge, thinking and learning capacity and also chronic underachievement in their academic studies. They are gifted academic learning disabled students or GALDSs (Munro, 2009).

Students in this group usually know they are comparatively high-level thinkers. They also know they are underachieving on key academic measuring sticks and they are aware that their peers are also aware of this. They may also display significant primary emotional or adjustment issues, such as Asperger's Syndrome and ADH/D.

The gifted underachievers in the present study (Munro, 2009) did not have primary emotional or adjustment issues. Nor were their learning disabilities attributable primarily to sensory causes such as hearing or vision impairment. They were in Years 11-12 in a large independent school in Melbourne, Australia, studying for the Victorian Certificate of Education (or VCE). They came from a larger group that had displayed chronic underachievement in at least half of their VCE subjects. They were either referred by teachers or self referred to the schools' learning support unit.

They were seen as having academic learning difficulties because of the knowledge they displayed in conventional summative assessment contexts. Their classrooms provided particular opportunities for their students to display their academic knowledge. Each assessment task provided a 'window of opportunity' for individuals to show what they knew. They needed to do this in acceptable ways. These students, while gifted, were rated by these tasks as having comparatively low academic knowledge.

The present study investigates the learning profiles of these students. To do this, it links the demands made by academic assessments with the extent to which these students meet these demands. It also describes an approach to intervention that draws on the research outcomes and that equips these students to meet these demands.

The measuring stick for academic success: The written analytic text response

Throughout their secondary education, students are required to show their knowledge of topics in a range of subjects by completing formal assessment tasks that involve skill in reading and writing. These include students needing to:

1. read and think in multiple choice question, short answer contexts; and,
2. display knowledge in longer written responses, for example, to write reports and factual essays.

To use an assessment task as a 'window of opportunity' to show what they know, individuals need to work within the parameters it provides. Essays rarely say 'tell me all you know about …' The students need to 'organise their knowledge' so that it aligns or 'fits with' the parameters of the task. The knowledge needs to synthesised or linked with the assessment task parameters. There are conventions that students need to know to show their knowledge in acceptable ways.

One of the most frequently used 'windows of opportunity' is the written analytic text response. It is one of the most common forms of assessment used in most of the subjects in secondary assessment. It requires students to interrogate and manipulate their knowledge of a topic in particular ways according to the assessment parameters and criteria. They may need to transform, reformulate and extend their knowledge, consolidate and review their understanding in terms of the assessment task demands and display their understanding in writing.

Evidence that some gifted students may have difficulty showing their knowledge in writing has been reported by Assouline, Nicpon and Whiteman (2010). Their cohort comprised students who had both an average verbal IQ of approximately 130 and a written language difficulty. They note that gifted students who demonstrate difficulty completing written assignments are often perceived to be lazy or unmotivated.

To display their knowledge in an essay, the students need to organise it in terms of relevant verbal linguistic propositions in a hierarchical way. The essay writing requires the writer to identify and use appropriately the topic, the main ideas linked with it and the details. These need to be organised and linked in paragraphs and sentences using the relevant writing conventions.

Before this the student interprets and understand task demands and links this with what they know. They may need to decide:

1. What the final outcome will 'look like'.
2. How they will align their knowledge with it.
3. How they will act on what they know to fit it into the 'window of opportunity.

From a cognitive perspective, the interface between the individual's knowledge and the assessment task demands is provided by the individual's short term working memory. This is examined in the next section.

The cognitive processes involved in the written analytic text response

The demands made on student knowledge by conventional assessment tasks that use the written analytic text format can be unpacked in terms of two components (Munro, 2009):

1. What students have learnt earlier about both the topic and how to display their knowledge in this form; and,
2. What students need to do to display their knowledge for the specific task.

The first component includes what the students have learnt earlier both about the topics targeted by the assessment and about the conventions of writing essays. This would include, for example, what they know about how to write paragraphs and sentences, how to spell. It also includes the extent to which their knowledge of topics is organised in verbal linguistic ways, for example, the extent to which it is structured hierarchically in verbal propositions.

The second component includes what the students can do now in terms of their cognitive and metacognitive activity in manipulating their knowledge so that they can express it in this form. It includes what they know about how to sequence the main and subordinate ideas and how to interrogate what they know in terms of particular task demands.

The cognitive and metacognitive activity implicated both during learning and while responding to assessment tasks is mediated by working memory processes. The role of working memory in transcribing and editing texts has been shown by Hayes and Chenoweth (2006). To facilitate inferences about the underachievement of GALDSs, it is useful to described briefly relevant aspects of the working memory processes.

It is useful to identify two aspects of working memory when individuals are completing a complex task such as an assessment task: a short-term, temporary retention process of limited capacity and a long-term aspect that includes knowledge and skills acquired earlier (long-term working memory) (Kessler & Meiran, 2010;

Sohn & Doane, 2003). These two aspects match the two components mentioned above. The first component matches long-term working memory and the second component matches short-term working memory.

The knowledge retrieved from the long-term store during an assessment task is used both to encode the task information and to complete the task. The manipulation of this knowledge according to the task demands is handled by the temporary short-term retention processes. Both aspects of working memory predict performance outcomes. Further, as the involvement by long-term working memory in a task increases, the demand on short-term, temporary retention decreases. In other words, the more an assessment task can be completed by knowledge an individual can retrieve automatically, the less demand there is on attention-demanding short-term memory processes.

The ways in which an individual's existing knowledge is organised determines the chunks that are available to be used in working memory processes during learning (Brooks & Shell, 2006). Learning is the interaction between one's existing knowledge, ability to learn and motivation to learn. Motivation in learning is the means by which attentional resources are allocated and maintained.

Individuals encode information in working memory by 'reading' it in multiple ways. They use what they know to do this (Chincotta & Chincotta, 1996; Kessler & Meiran, 2010; the 'activated long-term memory hypothesis'). They can code it phonologically by 'naming' parts of it. This involves articulatory activity, either saying aloud or subvocally parts of the information. They can do this for both visual and verbal information inputs. They can also code it conceptually or semantically, by linking parts of the information with meanings they have already stored (Deluged, Raffone & Belardinelli, 2009).

Baddeley's (2003) model of working memory explains the multiple encoding in terms of two different processes: the phonological loop that manages verbal material and the visuospatial sketchpad for processing visual-spatial material. Evidence for their dual use is shown in the serial recall of digits by verbal retention processes and the recall of block patterns by spatial retention processes (Alloway, Kerr & Langheinrich; 2010). Information in different modalities is mediated by different processes.

The activity of the two encoding processes and the manipulation of the retrieved knowledge in working memory activity to meet the demands of the assessment task is managed by a central executive. It does this in part by allocating attentional resources at any time and influences individual differences in working memory span. This aspect of working memory processing is associated with self-regulatory abilities and executive capability. It predicts achievement on reading and maths tasks and does so independently of verbal comprehension measured by the General Ability Index (Rowe, Kingsley & Thompson, 2010).

The encoding processes individuals use depend on the relevant knowledge they have stored in long-term memory. They encode better information that is more comprehensible. This is shown in the finding that lists of concrete words are retained more easily in verbal working memory tasks than matching abstract words (Acheson, Postle, & MacDonald, 2010). Both phonological and semantic coding facilitate the retention of the items processed.

Learning the conventions of writing

A key cognitive skill demanded in formal education is learning conventions. Conventions are learnt as statements or routines that students gradually internalise and learn to associate with meaning. When first learnt, these 'self statements' are arbitrary. Students learn these by 'being programmed' by their teaching; they represent key aspects of the teaching information as self talk.

Students learn the conventions for writing by encoding the teaching information phonologically. That is, they 'tell themselves what the information says'. This enables them to retain it in working memory. This has the status of 'learning it by rote' until they analyse it semantically and to 'make sense' of it by linking it with what they know.

Students encode the arbitrary information by using analytic sequential thinking as follows. They:

1. analyse the information into parts or details;
2. name these parts, and link meaning with them;
3. link them in the sequence in which they are presented, retain them with this organisation or sequence; and,
4. use this to synthesise the intended meaning .

Students learn to use the conventions for showing their understanding in writing as they progress through the primary and secondary school. To do this they apply analytic sequential thinking to written language input. If GALDSs have had difficulty benefiting from the earlier teaching to learn to use the conventions, they may have had difficulty using analytic sequential thinking. If this were the case, one would also expect the difficulty to be shown in their knowledge of spelling patterns.

The study examines whether GALDS have an analytic sequential processing difficulty that restricts their ability to learn and their use of essay writing conventions.

Working memory and gifted learning

While the analysis of working memory processes by gifted learners has attracted relatively little interest, the existing research shows that gifted children have better developed working memory capacity and use self-regulatory abilities more effectively than their average-ability peers (Duncan & Owen, 2001; Geake, 2008; Rypma, Prabhakaran, Desmond, Glover & Gabrieli, 1999). Enhanced self-regulation efficiency is linked with their elevated self-motivation (Calero, Garcia-Martin, Jimenez, Kazen & Braque, 2007).

Gifted students show better developed working memories than matched peers in two areas: verbal-numerical processing and visuo-spatial working processing (Vock & Holling, 2008). Both components are useful for measuring high cognitive abilities and explain substantial variance in school achievement.

When compared with non-gifted peers, gifted children show higher mental-attentional capacity, more rapid responses on speeded tasks of differing complexity and are more resistant to being distracted from tasks requiring effortful inhibition (Johnson, Im-Bolter & Pascual-Leone, 2003).

Implications for GALDSs

This review of the role of working memory in displaying knowledge in analytic written tasks leads to various predictions about GALD performance (Munro, 2009). To what extent is the academic underachievement of GALDSs associated with:

1. the long-term working memory processes; and,
2. the short-term working memory processes ?

Long-term working memory processes relate to the students' knowledge of written text structure, the conventions of writing and the subject or topic knowledge about which they will write. Given that the GALDSs are gifted in at least one domain of verbal and nonverbal knowledge, one would expect superior vocabulary knowledge and the ability to think creatively about topics. Possible causes of difficulty may be an immature knowledge of writing conventions and/or topic knowledge organised in non-linguistic ways.

As well GALDSs can be gifted in one or more domains of knowledge. The general learning patterns of students gifted in the nonverbal or visual-spatial domain have attracted increasing attention in recent years (see, for example, Mann, 2005). One might expect that verbally GALDSs may differ from their nonverbally GALD peers in their capacity to meet both the long- and short-term working memory demands of analytic writing assessment tasks.

Short-term working memory processes relate to the students' ability to encode information by processing it semantically and/or phonologically so that they have stored it as names. The capacity of short-term working memory is limited by the extent to which particular salient aspects of the information are identified uniquely by naming. It is possible that GALDSs may have difficulty with aspects of the naming process.

In summary, GALDSs meet the criterion of being gifted knowers and thinkers in what and how they think about topics they are learning. Their difficulty arises in aligning their knowledge with the 'window of opportunity' provided by the conventional knowledge assessment tasks.

Assessment tasks involve students linking their existing knowledge of a topic with the task parameters. GALDSs don't do this well. They are less able than their non-GALD peers to use the assessment tasks to show what they know. This research was aimed at understanding more about this difficulty. It examines patterns in the learning profiles of these students.

The participants in the present study

The GALDSs in the present study were selected using the broad criteria specified by Lovett and Lewandowski (2006): a comparatively conservative criterion for general ability and significantly below-average achievement in a subject area, and excluding other primary causes or explanations of the low achievement such as emotional or sensory difficulties. It was not seem as appropriate to exclude students who displayed low motivation to achieve academically.

The GALDSs displayed:

1. crystallised reasoning ability (ACER General Select) and/or fluid reasoning (Ravens Progressive Matrices-Advanced) in the top 10 % of their year cohort.
2. achievement in subjects in at least 4 of the 8 KLAs in the lowest 20^{th} percentile range over at least two school terms and for at least 3 assessment tasks in each subject.
3. creativity potential in the verbal and figural domains on the Torrance tests of creative thinking above the 80^{th} %ile for their year level.

The performance of the GALDSs (n = 42) was compared with a cohort of successful gifted academic learners (n = 45) and a cohort of average academically underachieving learners (n = 44). The GALDSs cohort was further divided into three subgroups depending on the domain in which they were gifted: those gifted verbally (the verbal GALD students, n = 11), those gifted nonverbally (the nonverbal GALD students, n = 18) and those gifted both verbally and nonverbally (the both gifted GALD students, n = 13).

The areas of knowledge assessed

The performance of the GALDSs (n = 42) was compared with the other two cohorts on the following tasks:

1. their ability to encode three types of arbitrary information in an analytic sequential way in working memory. For this, three tasks were used from the Detroit Test of Learning Aptitude (Hammill, 1998):
   i. visual symbolic information using the Design Sequences task;
   ii. connected verbal information using the Sentences Imitations task; and,
   iii. individual word information using the Word Sequences subtests.

2. their vocabulary using the Word Opposites subtest on the Detroit Test of Learning Aptitude.

3. their reading comprehension and orthographic skill using the English Skills Assessment (ACER, 1987).

4. the characteristics of their written analytic text response in English. The task required them to:
   i. recall the relevant content and to use it selectively;
   ii. organise and structure the ideas in the writing so that it communicates their intended message; and,

iii. use the conventions of written language, for example, sentence form and grammar, spelling and paragraph conventions appropriate to the specific purpose of the written task.

The students' ability in each of these aspects was rated on a 5-point scale. Each aspect was assessed as much as possible independently of the other criteria.

The results

Performance trends for the GALDSs in the short-term and long-term components of working memory and writing are compared with those of their gifted able peers and their non-gifted learning disabled peers. The trends are summarised here. They are elaborated in Munro (2009).

Trends in using the short term component of working memory
Four trends can be identified in the encoding of arbitrary information in a verbatim format in short-term working memory.

First, the ability of the three cohorts to encode the three types of arbitrary information in an analytic sequential way in working memory was compared. The GALDSs showed a similar information span in the three information contexts ($p > .05$). Further, they retained a similar amount of information in each context as did their non-gifted underachieving peers ($p > .05$) and less information than their gifted peers ($p < .01$). These data suggest that the GALDSs as a group are less efficient in encoding data verbatim in short term working memory than their gifted peers.

Second, the three GALDSs sub-groups were compared in their analytic sequential encoding ability. The following trends were observed:

1. The nonverbal GALDSs processed the three types of information less accurately than their verbal GALD peers and visual symbolic information less accurately than the both gifted group ($p< .01$).
2. The verbal GALDSs and both gifted GALDSs found the visual symbolic information easiest to encode and retain in order while the nonverbal GALDSs found the individual word sequence easiest ($p< .05$).
3. The verbal GALD group processed visual symbolic information more efficiently than their both gifted GALD peers ($p< .05$).

These trends are superficially counterintuitive but assist in elucidating the processing differences between the three sub-groups. If the assumption that the retention of the three types of information requires student to name the items to be retained, then, for those students whose verbal reasoning is lower than their nonverbal reasoning, language retention of information will be easiest when the information is presented in a named form. This group found the recall of sequences of individual words easier to retain than the other types of information. This would explain why the nonverbal GALDSs were more able to encode the verbal information; they were given the verbal labels here. Access to higher verbal ability allows the verbal and both gifted GALDSs to name the visual information verbatim more accurately.

These trends may be counterintuitive here. One might expect, for example, that nonverbal GALDSs would retain nonverbal information better than verbal. It needs to be remembered that the tasks here did not require students to reason about the information but to retain it verbatim. If phonological naming is required for this, the task for which the names of items are already provided may be expected to be easier to retain.

Third, comparison of vocabulary knowledge of the cohorts showed that the performance of the GALDSs fell between that of the gifted and non-gifted students. Of the three GALDSs sub-groups, those gifted verbally had higher vocabulary knowledge than those gifted only in the nonverbal domain. It is possible that the vocabulary task used here favoured those gifted verbally because it required the ability to link meanings in an abstract way. Alternative vocabulary tasks that asked students to recall word meanings in context may have elicited a higher score for the nonverbally gifted group.

The fourth trend related to the process of allocating names to the information to be encoded and retained verbatim. The efficiency with which individuals recall the items in order is assumed to comprise two components: the size of the set of names to which the individual has access (the individual's vocabulary) and the ability to allocate and retain the names sequentially. Removing the vocabulary score from the information span scores permits an analysis of the ability to name during working memory encoding.

Controlling for differences in vocabulary knowledge between the GALDSs, gifted and non-gifted categories did not affect trends in recalling the three types of information by each group:

1. The three cohorts continued to differ in the efficiency with which they retained the information. This is consistent with the GALDSs allocating names to information to be retained verbatim less efficiently than their gifted peers and with similar efficiency as the non-gifted peers.
2. The three types of information did not differ in the demands they made on analytic processing. This is indicative of the naming process in the three contexts.
3. Similar trends were observed when the three GALDSs sub-types were compared following the control of vocabulary size.

These findings suggest a characteristic of the academic learning profile of GALD students is in how they encode various types of information used in formal education. The three GALD categories were not homogeneous in this. The nonverbal GALDs processed the various types of information least effectively. Their learning patterns were more like those of the non-gifted peers. It is possible that the nonverbal GALDSs were less able to encode the information because their verbal naming capacity was less well developed.

The four trends described above relate to the use of the short-term working memory component of working memory (vocabulary also relates to the long-term component). The trends indicate both that the GALDSs differ from their gifted peers in how they encode arbitrary information in an analytic sequential way in working memory. They also show that the three subtypes of GALDSs differ in particular ways in the encoding process.

Trends in using the long term component of working memory
Three trends can be identified in the use of long-term working memory strategies to encode arbitrary information in a verbatim format.

The first relates to students' vocabulary knowledge. We have already noted trends in the vocabulary knowledge of GALDSs and their peers.

The second trend relates to the knowledge of literacy. This is shown in their reading comprehension skills. The three cohorts of students differed here; the GALDSs students did not differ from the gifted achievers and achieved higher than the non-gifted underachievers ($p < .01$).

The three sub-groups of GALDSs also differed in their reading comprehension. The nonverbal GALDSs achieved at a level similar to the non-gifted underachievers and below that of the verbal and GALDSs, who were similar to their gifted achieving peers. The students who were gifted in both areas lay between the two extreme groups but closer to the verbal GALD students.

The third relates to the influence of the knowledge domain in which the GALDSs are gifted on their working memory processes. The data show that the nonverbal GALDSs used phonological naming less successfully than their GALDS or their gifted peers.

The characteristics of GALDSs writing in written assessment responses
A second aspect of students' long-term working memory is what they know about expressing their knowledge in writing. Written assessment outcomes for the GALDSs, their gifted peers and their non-gifted underachievers on five extended written responses were evaluated and scored in terms of the three key criteria:

1. Knowledge and control of the chosen content.
2. Organises and structures coherently the ideas in the writing.
3. Uses the writing conventions to communicate effectively.

A number of indicators were used for each criterion. For each criterion, each student's written response was scored on a 5-point scale ranging from low (1) to high (5).

The verbal and both gifted GALDSs showed higher performance than the nonverbal GALDSs on the criteria 1 and 2 above ($p < .05$). The nonverbal GALDSs and the non-gifted underachievers showed similar achievement levels. The performance of the GALDSs was below that of their gifted peers on all criteria. These trends show that the GALDSs had a comparatively impoverished knowledge about how to display their knowledge in writing.

A writing profile was prepared for each student. This was used, as described in the following section, to implement an intervention for each student.

An intervention that targeted teaching working memory strategies for displaying knowledge in extended written assessment responses

The GALDSs were involved in an extensive intervention that taught them various aspects of how to express their knowledge in written tasks. The intervention did not teach the students new content area knowledge but rather how to align their knowledge with assessment tasks and to display a response in writing.

The intervention covered the following areas:

1. Naming activities; these targeted teaching students to encode their existing knowledge of a topic in a verbal form and included teaching them to name key vocabulary for a topic, and to describe in sentences what they 'see in their minds'.
2. Telling themselves about an assessment; this targeted the students learning to paraphrase what a task said and to visualise their finished written response might 'look like'.
3. Using self talk that guided them to organise what they know so that they achieve the intended purpose; this included the students learning self talk that directed their attention to the questions to be answered by the response, the extent to which the topic or overall message is conveyed, the relevance, depth and breadth of ideas, the vocabulary used, the sentence and paragraph ideas.
4. Using self talk that guided them to organise and sequence the main ideas, the ideas in paragraphs and in sentences.
5. Using self talk that guided them to use a range of writing conventions, for example, to introduce, develop, conclude, to linked paragraphs coherently, to write sentences and paragraphs.

In each of the areas the focus was on the students learning to use self instruction that guided them to use the appropriate strategies independently and automatically. To achieve this, each area was taught in the following sequence:

1. Recognition tasks; the students were taught to recognise when a particular writing criterion was or was not being used. For a student learning how to improve the depth and breadth of the ideas they were expressing, they were asked to discriminate between samples of writing that met the criterion and ones that didn't.
2. Scaffolding for strategy/action; the students were scaffolded by the teaching to use the criterion in their writing.
3. Teach the relevant self talk; the students described aloud the thinking /strategies they used to meet the criterion in their writing as they used them. This enabled them to code the writing strategy as self talk that they could transfer to other writing contexts and use in the future.
4. Automatise the self talk; before the students began to express their knowledge in writing, they said aloud what they would do, the strategies they might use. This enabled them to use the self talk to direct their writing activity when responding to assessment tasks and to use it independently.

An individual intervention program, that drew on the five areas above, was implemented for each student, using their writing profile. The intervention followed a 'dynamic assessment' regimen that followed the four-phase teaching sequence to independence described above for each criterion. Each student continued to receive instruction on each criterion until they displayed it independently in five typical written responses to assessment tasks. In terms of the number of separate 'learning trials' for each criterion at each phase, the data indicate:

1. the nonverbal GALDSs needed more learning trials than their verbal and both GALD peers at the recognition, scaffolding and self talk phases for each criterion; their peers were more likely to have their existing knowledge of topics organised in verbal ways.
2. the nonverbal GALDSs were more likely to need instruction in naming, talking about their understanding of a topic in sentences, identifying the questions it answered and organising their topic knowledge in verbal ways.
3. the verbal and both GALDSs did not differ in the quality of the intervention they needed to achieve criterion writing achievement.

Discussion and conclusion

The findings of the present study elaborate and extend earlier investigations. First, they identify a cognitive cause for the underachievement of some gifted learners. While earlier investigators such as Mann (2005) have noted the learning outcomes displayed by these students, the present study assists in explaining them.

Second, the study indicates the types of tasks that can be used to identify the learning patterns of GALDSs. Tasks that require the allocation of names to information, whether it be verbal or visual, can be used to monitor the ability to 'self name' and to retain in a sequence.

Third, the study offers a research-validated approach to intervention for GALDSs at the senior secondary level. The intervention is referenced on each students' particular writing profile. It is reasonable to expect that GALDSs would exist in the student cohorts of most secondary schools. The intervention is systematic and explicit and able to be implemented by teachers who understand both the cognitive demands of expressing writing knowledge in writing, dynamic assessment procedures and strategy teaching to independence.

In common with primary-age gifted students who have literacy learning disability, the GALDSs had difficulty using analytic sequential information processing strategies. In this present study, these had influenced their knowledge of the conventions of writing and, for the nonverbal GALDSs, the encoding of their knowledge and understanding in verbal linguistic forms.

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