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Evidence-based Reasoning Processes in Education: A Model to Support Interventionist Practice.

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Abstract: The Evidence-based Reasoning model is a systematic inquiry into student learning to determine what interventions are required in classroom contexts. The four step process includes noticing students who need additional support in their learning, the use of assessment data to establish an evidence-base, and subsequent interpretation that leads to decision making. The reasoning process is supported by collaborative practice models both within and beyond the teaching profession. The evaluation of interventions is integral in determining the impact that interventions have on student learning.

Introduction

Evidence-based reasoning is based on the philosophy that teaching is a profession that involves using evidence and research to make judgements (McLean Davies, Anderson, Deans, Dinham, Griffin et al., 2013). With the introduction of evidence-based practice in initial teacher education courses and more broadly across the teaching profession, this paper proposes a framework for reasoning that supports educators' decision-making processes. Targeted teaching is focused on the student, their learning progress and targeting interventions to meet their needs (Redman, 2014). ***Evidence-based Reasoning*** is a process to support decision-making about student learning and determining what the next steps should be. While developed within the context of education, this framework has resonance with clinical reasoning pathways that are well established in other professions that support students in schools, such as speech pathology.

While the central focus of teaching is students' learning development, effective teaching is also about relationships (McLean, Angelico, Hadlow, Kriewaldt, Rickards, Thornton & Wright, 2017). It is essential that the teacher-student relationship is positive, supportive and affirming. Strong positive relationships and professionalism are also important when working with parents, colleagues and other professionals (eg. allied health) to support decision-making processes with respect to student development.

Developing an Evidence-based Reasoning Model

In education settings, collaborative practice models – for example, with teachers and speech pathologists working together to address children's learning needs - are considered essential in building a Team Around the Learner. Teachers need to know how to engage in collaborative, cross-disciplinary problem solving to best support students who are potentially at risk of not being able to access curriculum or becoming disengaged from school, resulting in a reduction in access to quality education. The aim of this Educational Design Research project was to create case studies that could be used to support collaborative practice between

pre-service teachers and speech pathology students. Educational design research can be used to address complex issues pertaining to educational practice through 'designing, developing and evaluating educational interventions' (Plomp & Nieveen, 2010). Therefore, in 2018, an initial pilot was trialled using parallel case studies with approximately 160 Master of Teaching and Master of Speech Pathology students completing their final year at the University of Melbourne. Students in both cohorts worked through an in-depth case study and the lecturers shared responses from both cohorts to support 'parallel' collaboration. During the trial, it became evident that some participants were making assumptions regarding the students represented in the cases based on initial intuitive responses and in some instances, immediately diagnosed students in a way that extended beyond their scope of practice.

This issue was addressed in the next iteration of the Design Research project that involved planning a collaborative case study that would be undertaken in a combined tutorial with both Master of Teaching and Master of Speech Pathology students. An essential tool that needed to accompany this process was a model that would guide reasoning processes, initially to slow down the decision-making process, but also to ensure that all the necessary information had been generated and analysed to support valid decision-making. A comprehensive literature review was undertaken and a model was created based on the research evidence in education and other fields. A concordance activity was conducted with five expert teachers and speech pathologists to determine their reasoning processes when completing a case study and to test the efficacy of the Evidence-based Reasoning Model. The subsequent implementation of the model and case study was successfully implemented during both parallel and collaborative tutorials with pre-service teachers and speech pathology students. One of the tutorials was conducted in the Science of Learning Research Classroom at the University of Melbourne, which is a purpose built facility containing 16 high definition cameras and microphones that are positioned unobtrusively to enable the recording of interactions. Subsequent data analyses included coding for each step in the reasoning model and discourse analysis to map reasoning and argumentation processes in collaborative groups. Further, we implemented interdisciplinary placements for Teacher Candidates and Speech Pathology Students, which have never been offered before. Some students had the opportunity to work in the same school settings, working collaboratively with each other and developing plans to target the needs of students (supported by Teaching Mentors and Clinical Educators).

This process highlighted the need to develop an Evidence-based Reasoning model to support the identification of students requiring targeted support and universal strategies that can be applied in the classroom context. The following paper provides a theoretical explanation of a model that describes the processes that were identified as critical when engaging in Evidence-based Reasoning. The components of the model are methodical and incorporate key considerations that can support a rigorous approach towards decision-making. The use of the term 'evidence' is now commonplace in justifying classroom practice. However, it was very clear from the outset, that a stable and practical definition of 'evidence' needed to support this work. For the purposes of this paper, 'evidence' refers to 1) the research-base that can be drawn upon to justify reasoning processes, and 2) the evidence that is generated in a classroom by teachers through observations and assessments. The research 'evidence' and the 'evidence' from teacher assessments supports reasoning that leads to evidence-informed decision-making.

The Evidence-based Reasoning Model

Evidence-based reasoning is a process that focuses on learning about a student in order to make decisions that are going to meet the student's needs. It requires a deliberate, coordinated, evidence-based and interventionist approach. In a study examining the teaching of clinical reasoning in allied health, Delany, Golding, and Bialocerkowski (2013) found that 'it is possible to identify and make explicit the thinking steps that underpin clinical reasoning' (p. 51). The process used in the study was to frame questions to guide clinical educators when teaching and supporting the development of clinical reasoning. The use of questions to support clinical reasoning is a feature of the evidence-based reasoning model introduced in this paper for the education profession. Rather than leading to patient diagnosis, evidence-based reasoning in education refers to the process of determining what the student can do now and what they are ready to learn next.

The Evidence-based Reasoning model presented here has been developed based on a cross-disciplinary literature review, with reference to the fields of education, allied health, medicine, neuroscience, nursing, philosophy and psychology. It provides a detailed, four-step model that guides teachers and teams to build their knowledge of students using evidence, and then careful deliberation to translate that evidence into practical interventions that are targeted, achievable and impactful. The model is, by design, a conceptual construct that represents comprehensible processes. However, there are resultant tangible products, such as the data that is generated and the subsequent plans that are put into action. The reasoning processes must move from a conceptual construct to an action that is implemented and evaluated as 'the intervention'. As a representation of the reasoning process, it also provides a guide for case-based learning. The model is presented in figure 1, and each step in the model is described in the following sections.

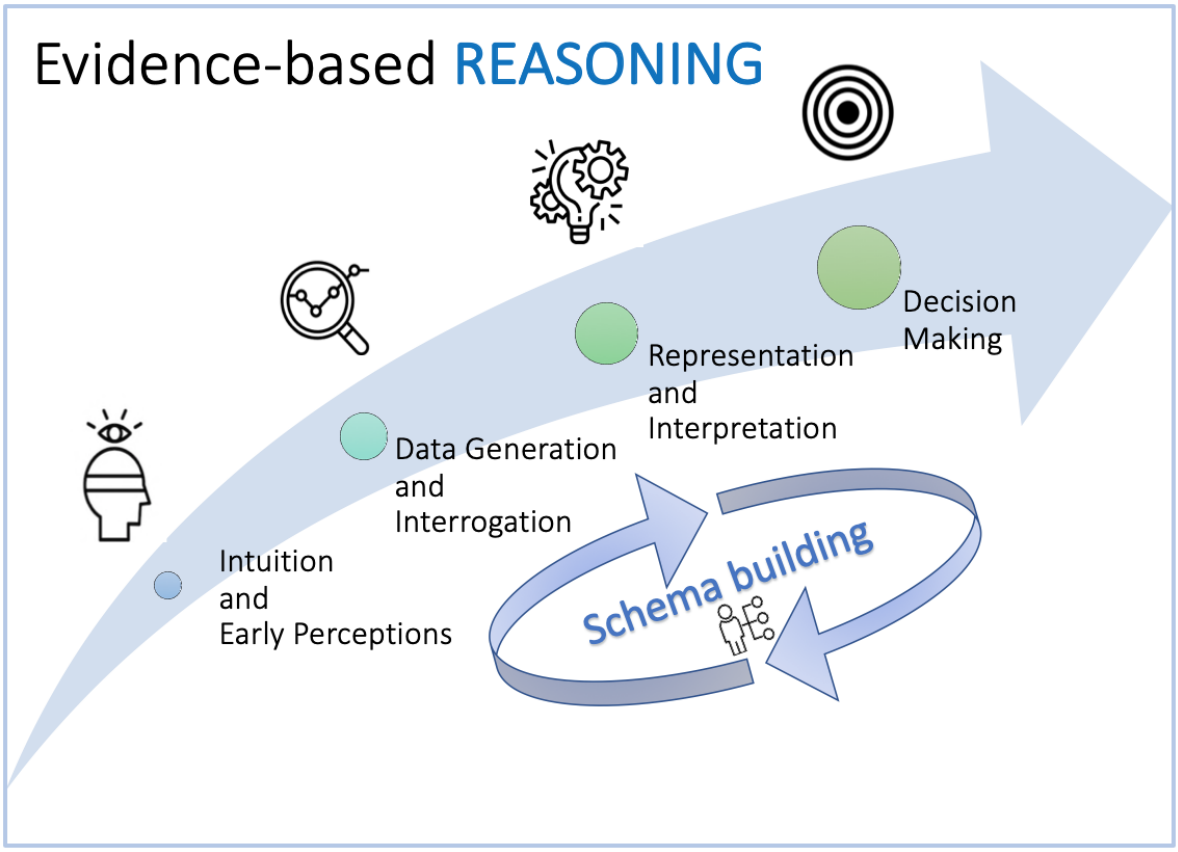

Figure 1. Evidence-based reasoning process

Intuition and Early Perceptions

The questions that guide this process are:

- **What do you notice about the case?**
- **Is this worth investigating further? Why?**
- **How will this be investigated further?**

Intuition and early perceptions are important cognitive processes that are critical for '***noticing'*** when a student requires additional support by undertaking a rapid first assessment. A dual process occurs of noticing and making a judgement about validity, which highlights the importance of the 'Why?' question. Intuition and early perceptions provide a basis on which to act further, so early perceptions should inform the first actions. McCutcheon and Pincombe (2001), found that 'intuition is not something that just `happens'. Rather, it is a result of a complex interaction of attributes, including experience, expertise and knowledge, along with personality, environment (and) acceptance of intuition as a valid `behaviour'' (p. 345). Therefore, a teacher's experience, knowledge and expertise are acknowledged as valuable tools in the capacity to initially notice a student that might be experiencing difficulties and requires additional support. Price, Zulkosky, White and Pretz (2016) found that student nurses made more accurate judgements when using intuition in familiar situations, versus focusing immediately on analysis of data for decision-making, as their attention was focussed on the relevant cues. However, in unfamiliar situations, using intuition alone hampered decision-making. Thus, for novices, it is particularly important to explicitly consider whether intuitions are likely to be valid (Price et al., 2016).

While more experienced teachers will initially have stronger intuitive responses, even the most experienced teachers might observe a pattern of behaviour and find that regular approaches are proving to be ineffective. It is essential that this is recognised as an issue and explored further.

> *[A person] is set in [their] ways, and [their] immediate appreciations travel in the grooves laid down by his unconsciously formed habits. Hence the spontaneous "intuitions" of value have to be entertained subject to correction, to confirmation and revision, by personal observation of consequences and cross-questioning of their quality and scope. (Dewey, 1960, p. 132)*

Thus, for both novice and more experienced teachers, intuition and early perceptions can be fallible, which is why a decision regarding '***further investigating'*** needs to be made as objectively as possible, by considering the appropriateness and validity of personal intuition and perception (Dreyfus, 2004; Jefford, 2011). Further investigation involves the use of data as sources of evidence for more deliberate analysis, optimal reasoning and decision-making. Novices in particular might require further support at the intuitions and early perceptions stage by sharing them with a more experienced peer in order to consider the validity of their perceptions.

Key questions to support this process include:

- Have I seen this before?
- What does this look like that I am familiar with?
- Is this worth investigating further? Why?

Data Generation and Interrogation

Data generation and interrogation serves to buttress *intuition and early perceptions* and is underpinned by the foundational statement that facts are important. Therefore, *evidence* in this context is defined as the information that is discovered or generated by the teacher to establish facts about progress in learning. The two purposes of Data Generation and Interrogation are to:

- **Create a plan and generate data**
- **Analyse data to determine the student's level of achievement and areas where support is needed.**

To support reasoning, a decision needs to be made about what data will be informative and how much is required. The purpose of the data is to support reasoning, and this requires a plan to determine what the evidence palette needs to look like (Gauthier, 2014). Potential data sources include observations, questioning, assessments, work samples, conferencing, anecdotal records, discussions with the student and parent meetings. The data should be objectively recorded, low inference and clearly identify the level the student is currently working at and where they need to go next, as well as identifying areas of difficulty or where additional support or strategies are needed. The use of a research-based learning progression can be used to locate current and potential progress:

> *A learning progression provides a frame of reference for establishing where each student is in their learning and for monitoring growth over time. It is an empirically based map of typical progress in an area of learning that describes and illustrates increasingly sophisticated understandings, increasingly deep knowledge and increasingly advanced skills in that area. (Cawsey, Hattie & Masters, 2019, p. 3).*

The use of data against learning progression is comprehensively addressed in Griffin's (2017) work, which can be used to support the analysis of data. In more complex cases, planning an evidence-informed conversation and moderating this data with an expert teacher or team further strengthens the analysis. This includes the process of articulation, probing and interrogation to be made more explicit (Kriewaldt & Turnidge, 2013).

Data that has been generated by the teacher then needs to be interrogated for validity and potential for eliciting meaning. For novice teachers in particular, explicitly stepping through a process of questioning of the data can be a useful scaffold, using questions such as:

- Do I have all the information I need to support the analysis of data?
- Are there any gaps in the information?
- Is the data an accurate and objective representation of the student's level based on my prior knowledge of the student and the expectations of that level?
- Does the information tell me what the student can do and what they need to be able to do next based on a learning progression outlining the 'typical sequence' of learning in this area?

Further data should be gathered and examined to meet any gaps identified above.

Representation and Interpretation

Representation and Interpretation is essentially an articulation of the case and a meaning-making process. The Oxford dictionary defines *representation* as 'the description or

portrayal of someone or something in a particular way' and *interpretation* as 'the action of explaining the meaning of something' (Oxford Dictionary, 2019).

- **How can I represent the student's learning and learning challenges, based on the data?**
- **What other information do I need (research, professional conversations with colleagues) in order to strengthen interpretations about the needs of the student?**
- **What are the key targets for intervention?**

The first *representation* of the case involves taking all of the available evidence that has been generated and phrasing the key issues in a way that summarises and describes the case. When information is represented, this is essentially a process of identifying key terms or phrases that can be used to ask a colleague or health professional for assistance or could be used to source research. Through representation and interpretation in a collaborative practice setting, tacit inferences are made explicit (Kriewaldt, 2013).

There is generally a lot of information and advice that can potentially be used for any area of learning, behaviour and communication, but an essential skill is being able to discern what is evidence-based, useful, practical and appropriate. Any additional information can confirm, discredit or build on the initial early perceptions. Therefore, it might be necessary to re-evaluate the information that has already been constructed and to go back to the data generation and interrogation phase. Evidence-based reasoning is not a linear process and looping back through the reasoning process might be necessary to strengthen the evidence-base and to support any inferences that are being made as a result of the data.

Representation and interpretation is a conscious process of deliberation and can be used as a 'think-aloud' protocol with colleagues and health professionals to assist with interpreting the case (Higgs, Jensen, Loftus & Christensen, 2019).

Key questions to support this process are:

- Who is this student, situated in the classroom context? (describing the key points that identify this student's strengths and challenges)
- What do I know about supporting this student, and what do I need to know?
- Who can I talk to, or where can I look, to strengthen my knowledge about supporting this student?

Decision Making

Decision making and judgement are the ultimate goal of evidence-based reasoning (Holder, 2018). Decisions should be based on evidence and good reasoning.

What actions do I need to take?
How will I do this?

A decision is the result of knowledge and expertise interacting with new information and data, and, if appropriate, further research, parent meetings, discussion with the students about their needs and what they know will help them, and collaboration with colleagues and other professionals. Simply undertaking this process of evidence-based reasoning does not guarantee that an accurate decision will be made. This is largely is dependent on the initial accurate intuition and perception, the capacity to collect and interpret the right data, represent and interpret it, and an understanding of the variables that could potentially impact on

learning (Levett-Jones, Hoffman, Dempsey et al., 2010). Key also is previous experience, built into schemas which support this reasoning to be done accurately and efficiently.

> *For teachers to use evidence to improve teaching and learning in their classrooms they need information about what their students know and can do, evidence about their own practice and its impact on students, and knowledge of the research evidence and that from other established sources to give direction for improvements to practice (Timperley, 2010) .*

Evidence-based reasoning requires a thorough and thoughtful approach, and careful consideration of all factors in order to implement appropriate interventions. This is essentially a metacognitive task that requires monitoring of thinking throughout the reasoning process. The key to effective decision-making is to ensure that it is evidence-based, timely and targeted appropriately.

Kriewaldt and Turnidge (2013) highlight the importance of probing personal assumptions with evidence to critically evaluate decision-making and teaching approaches. To limit erroneous assumptions, reasoning processes should test assumptions, ensure that decisions are based on facts and accurate interpretation of data and involve ongoing evaluation of impact. Decision-making requires time and can be negatively impacted on when decisions are made prematurely and without the necessary evidence being considered.

The key questions to support this process are:

- Have I checked my assumptions and used evidence in the decision-making process?
- What intervention/s would be most suitable considering the student, context and availability of time and resources?

The latter is the area where novices may need the most support. For students with complex learning challenges, discussion with other professionals in speech pathology, psychology or occupational therapy, may support the identification of interventions that can be trialled. Similarly, experienced peers may have ideas that address specific needs and have worked successfully. Key to decision-making for both novice and experienced professionals is that it is not a ‘one-off’ decision. Decision-making about a particular intervention(s) should be seen as a starting place, which will guide further data collection, analysis and representation, and adjustment of interventions over time.

Evidence-based Teaching and Interventionist Practice

Interventions are actions that are taken to support students at school. All students will require immediate intervention at some stage of the learning and teaching process. Some student will need targeted short-term interventions. Some students will require ongoing interventions to meet long-term needs and require a student support group. An intervention is ‘teaching’ and can constitute providing feedback and additional instruction to a student, or can be a more comprehensive, longer plan to meet a student’s needs. Longer term interventions should be planned for students who are experiencing challenges with their schoolwork, communication, behaviour, directing attention, concentration and fitting in socially.

Some students will require ongoing interventions due to the challenges they are experiencing at school. There are students who have ongoing significant needs and the support requirements will vary. The reasons why students move through school without being identified as having additional needs, or parents choosing not to pursue a diagnosis are complex issues that will not be addressed by this paper. Our stance is that irrespective of diagnosis or funding, a student that is experiencing challenges at school should have their

needs met and if necessary, a student support group and an individual learning plan created to support them.

The Role of Schemas in Evidence-based Reasoning

Evidence-based reasoning is a cognitive process based on schema building theory. Schemas are dynamic knowledge structures that are highly organised, complex categorisation schemes that help people make sense and meaning of the world around them. Building schemas involves new knowledge and information being integrated into existing ways of thinking based on experience, knowledge and values. Representations of schemas are sometimes shown as concept maps. However, this provides a simplistic representation of how schemas are developed from an ecological perspective. For the purposes of this paper, Anderson's (1971) definition of schemas will be used:

1. *Schema are transformative (they are reorganized when incoming data reveal a need to restructure the concept) and represent a personal ontology (they are organized in a way that is meaningful to the individual)*
2. *Schema tend to be irreversible (schema are malleable and changeable moment-by-moment as information is received)*
3. *Schema are integrated (schema are embedded in other schemata, which themselves subsume sub-schema)*
4. *Schema are bounded (schemas enable gestalt or holistic representations which recognize the boundaries between concepts)*
5. *Schema can represent 'troublesome knowledge' (they often run counter to common sense and have a strong affective component). (Anderson (1971), in Walker, 2012, p.251)*

While traditionally situated within cognitive psychology, McVee, Dunsmore and Gavelek (2005) frame schemas within both cognitive and sociocultural theory and identify three key points that are acknowledged for the purposes of the CREST model, and in relation to schema theory:

(1) Schema and other cognitive processes or structures are embodied— that is, who we are as biological beings determines our sensorial interactions with the world and thus the nature of the representations we construct;
(2) Knowledge is situated in the transaction between world and individual; and
(3) These transactions are mediated by culturally and socially enacted practices carried out through material and ideal artifacts. (pp. 555-556)

Schemas become more elaborate as expertise develops and new information can be more efficiently categorised and integrated with more complex existing schemas in long-term memory. This system of organising knowledge sequentially is necessary to achieve a goal, and generally represents a typical sequence of events. With developing expertise, schematic knowledge becomes more complex and are used to assist with the cognitive processes of reasoning. Experienced professionals can utilise multiple schemas and efficiently utilise existing scripts to make judgements about relevant and non-relevant cues to inform decision-making (Holder, 2008).

The evidence-based reasoning process is supported by the role of scholarly inquiry as schemas are developed in relation to a particular case. As schema become more complex in the development of intuition, knowledge and expertise, there is an increase in flexibility and efficiency of decision-making (Banning, 2008). Knowledge about the case is organised in a way that allows for rapid retrieval of information, interpretation and immediate efficient

action. Qiao et al. (2014) state that expertise is, among other factors, a result of complex decision-making trees, and that exemplars from 'experience might be the most significant difference between novices and experts'. Darling-Hammond (2016) highlights the importance of 'supervised clinical training along with more thoughtfully organised coursework' in initial teacher education programs (p. 311). To support novices in becoming experts, new information and knowledge requires appropriate scaffolds so that new information can be integrated into meaningful knowledge (Qiao et al., 2014). Collaborative practices and mentoring that focus on evidence-based reasoning can model and support the decision-making processes for novice teachers.

Evidence-based Reasoning Example 1: Interventions to Meet Immediate Needs

Evidence-based reasoning in the short-term can be used to take immediate action. That is, the approach can support teachers to understand what can be done immediately to support a student, using minimal intervention for maximum benefit to the student.

Case

In a grade 5 mathematics class, Joe is comparing sets of two decimals and identifying which one is larger. Joe has recorded that 1.18 is larger than 1.9.

Intuition and Early Perceptions

Joe is having difficulty with place value when comparing decimals.

Data Generation and Interrogation

The teacher asks Joe to explain why he has recorded the answer. Jo states that 1.18 is bigger because 18 is larger than 9. The teacher confirms that Joe is aware that both numbers are between 1 and 2.

Representation and Interpretation

Joe has a longer-is-larger misconception and more specifically, is treating the decimal numbers as whole numbers. The representation and interpretation, building on the data generation and interrogation stage, provides a more in-depth understanding of Joe's learning and supports the identification of the interventions that will best support Joe. The longer-is-larger misconception is quite common at this year level and, in this example, the teacher uses their existing schema of how students learn decimal place value, combined with the evidence from the student's responses to determine what the student knows and what the student is ready to learn next. They also access research showing that using concrete materials such as Linear Arithmetic Blocks are effective for addressing this misconception (Stacey, Moloney & Steinle, 2004).

Decision-making

The teacher decides that more time needs to be spent using Linear Arithmetic Blocks to provide a clear visual model of the value of the numbers in the tenths and hundredths columns. The teacher implements this with a plan to evaluate after X lessons, using further discussion with Joe and regular checking of his mathematics workbook to determine if he has developed his understanding.

Evidence-based Reasoning Example 2: Interventions to Meet Longer-Term Needs

Case

Aaron is 6 years old and has just started grade 1. He finds writing very tedious and takes a lot of breaks during writing activities.

Intuition and Early Perceptions

The teacher notices that Aaron has difficulties during writing tasks across all learning areas. This warrants further investigation due to the impact on academic progress and Aaron's self-efficacy.

Data Generation and Interrogation

The teacher observes Aaron's writing behaviour during class. Aaron is not using the typical pencil grip, using all five fingers to hold the pencil. He holds on to the pencil very tightly that results in Aaron pushing down hard on the pencil while writing. He regularly shakes his hand because it 'hurts' and overall, his rate of writing progress is slower compared to other students at this level. The teacher also observes that Aaron has difficulty using scissors, holding them incorrectly and cutting slowly compared to other children. The teacher organises a meeting with Aaron's parents to discuss the challenges he is experiencing during class. Aaron's parents also note that he has trouble using cutlery at home and tends to eat with his fingers. They have bought him shoes with velcro straps because he cannot tie his shoelaces.

Representation and Interpretation

The teacher concludes that Aaron is experiencing difficulty with fine-motor tasks, which impacts on his physical comfort levels, resulting in fatigue. He is showing signs of frustration when completing writing tasks, which is impacting on his engagement.

Decision Making

A recommendation is made for Aaron to see an occupational therapist for an assessment. In the short-term, the teacher will make accommodations by providing Aaron with a pencil-grip so that he can hold the pencil more comfortably. The teacher will continue to provide Aaron with a lot of opportunities for practising his writing and the use of scissors.

When showing signs of fatigue, the teacher will provide additional support for recording ideas and information by assisting Aaron with a short writing break and writing brief notes about his ideas. Using a computer (typing instead of writing) will be offered sometimes to support Aaron to engage with, demonstrate and develop his written language skills, without relying on his handwriting. When further recommendations are provided by the occupational therapist, the teacher will make additional accommodations to support Aaron and his engagement during writing tasks. The teacher determines that she will work collaboratively with the occupational therapist to determine appropriate evaluation of Aaron's progress with respect to fine motor skills, and will herself monitor his engagement in written tasks, whether these are using handwriting or alternative (eg typing) means, in order to inform her whether the interventions are supporting Aaron.

Ethical Responsibilities

When engaging in evidence-based reasoning, there is an ethical responsibility when making decisions about students and when planning subsequent interventions. The fundamental right for all to have access to education is enshrined in the Universal Declaration of Human Rights (UNHDR, 1948), the Salamanca Statement and Framework for Action (UNESCO, 1994) focusing on inclusion in education and is legislated and enacted through codes established by local authorities in every Australian state or territory. For example, the relevant standards in the *Teaching Professional Code of Conduct* for the Victorian Institute of Teaching include:

Principle 1.1 *Teachers provide opportunities for all learners to learn*

Principle 1.2 *Teachers treat their learners with courtesy and dignity*

Principle 1.3 *Teachers work within the limits of their professional expertise*

Principle 1.4 *Teachers maintain objectivity in their relationships with learners*

Principle 1.6 *Teachers maintain a professional relationship with parents/carers*

Principle 1.7 *Teachers work in collaborative relationships with learners' families and communities*

Principle 1.8 *Collegiality is an integral part of the work of teachers.*

Principle 3.1 *Teachers value their professionalism, and set and maintain high standards of competence*

Principle 3.2 *Teachers are aware of the legal requirements that pertain to their profession. (VIT, 2015, p.2-4).*

The goal of providing opportunities for all students to learn and understanding a teacher's scope of practice, as bounded by the profession, is important in determining what support is required and whether a student support group needs to be established. The core student support group is the teacher and the child's parents; however, it might be appropriate to include a special education teacher and allied health professionals to draw on their areas of expertise to support planning interventions.

Conclusion

To engage in evidence-based reasoning is to undertake a systematic inquiry into student learning. Evidence-based Reasoning involves 1) noticing students who require additional support; 2) the iterative use of data and assessment to establish the evidence-base

for interpretation; 3) knowledge about research-based learning progressions of *typical* development; 4) implementation of appropriate interventions. The process is supported by a deep understanding of how students learn and engaging in evidence-based reasoning itself supports ongoing schema building which in turn facilitates more efficient, flexible and stronger reasoning. Evidence-based Reasoning also requires ongoing evaluation of interventions and their impact of teaching on student learning. The features of the reasoning framework can be used for developing competence in novice teachers and support developing expertise. Collaborative practices serve to strengthen interventions and the outcomes for students by utilising expert knowledge both within and beyond the teaching profession.

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