ANALYZING A CASE STUDY: METACOGNITIVE ASPECTS OF A VOCABULARY INSTRUCTIONAL APPROACH

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Abstract

Vocabulary instructional tools can be used in the science classroom to increase students' understanding of course terminology. This thesis used a case study approach to explore the Etymological Approach to Learning Biological Terminology [EALBT] used by an instructor to ease access to university-level terms. The results indicate the existence of five unique approaches to the EALBT and that a number of metacognitive elements can also be integrated into this instructional method. The conclusions include that university science courses can require more self-guided learning when compared to high school science. Likewise, metacognition can develop skills in thinking and learning control processes that could lead students to become increasingly apt at accessing course material, including terminology.

***Keywords*:** terminology, metacognitive instruction, vocabulary etymology, morphemic instruction

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Analyzing A Case Study: Metacognitive Aspects of a Vocabulary Instructional Approach

Students face challenges when learning vocabulary in science courses in part due to the polysyllabic and technical nature of the terms (Krajcik & Sutherland, 2010), as well as their considerable number (Fisher & Blachowicz 2013). Science terms can often derive from languages not often taught in traditional western classrooms such as Latin and Greek, languages that students may not have studied in the past (Voultsiadou & Gkelis, 2005). Insufficient vocabulary knowledge, as Zukswert et al., (2019) researched, contributes to low achievement by erecting a barrier to assimilating course content. In response, students can gravitate towards rote memorization to cope with the burden of the vocabulary (Mayer, 2002). Memorizing terms also occurs in introductory undergraduate science courses where large class sizes can reduce interactions between individual students and their instructors which then can compound with the lexical requirements of a course to reduce engagement and performance (Dye & Stanton, 2017; Stanton et al., 2019). The challenges outlined for science vocabulary instruction are equally applicable for specific biology courses in universities, for instance anatomy or zoology courses.

The Etymological Approach to the Learning of Biological Terminology [EALBT] is a vocabulary instructional approach used by Professor Brown to introduce specialized terminology to university undergraduate biology students (Brown, 2014). The EALBT uses morphemes, which are the smallest meaningful unit in language, and the historical origin or the morphemes, to ease the access to vocabulary terms (Scott et al. 2011). Morphemic instruction can be useful for science terms (Lane et al., 2019), as an example, the word *dendrochronology* can be broken down into three morphemes: *dendro* (tree), *chrono* (time), and *ology* (study of). Although this term could be novel to students, if it is taught using a morphemic approach, students without explicit formal knowledge of the term can derive meaning from its parts (Baumann et al., 2003). That is, someone unfamiliar with the term *dendrochronology* could then extrapolate the meaning of the word: a method used to date trees.

In conjunction with the use of methods such as the EALBT, there are learning tools that can use to overcome challenges students face in the classroom. Researchers, such as Flavel (1976) posit the importance of metacognition for learning. Metacognition is colloquially defined as “thinking about thinking” (Rhodes, 2019). Moreover, it refers in part to a learner’s understanding of their own learning and thinking processes (Radovan, 2019). Developing

metacognitive skills encourages self-regulated learning because it can increase students' understanding of their course material (Magno, 2010). Research has shown that students with developed metacognitive skills can use such learning strategies to understand their course material independently (Hartman, 2001). Learning strategies can be particularly important for undergraduate students because their classes generally require more self-sufficient learning when compared to high school (Colthorpe et al., 2018). Adding metacognitive aspects of instruction to the EALBT could have benefits for students and aid them in becoming more sufficient learners. I explored the means by which a professor could make a vocabulary instructional tool (specifically the EALBT) metacognitive.

Dye & Stanton (2017) found that students in university level biology courses are more likely to use metacognitive control measures when compared to high school science students. The researchers determined that the increase in metacognition is in part the student's response to unsatisfactory grades and is additionally a response to the increased difficulty of course material in university level courses. Therefore, analysing an introductory university science course for the addition of metacognitive instruction would be relevant because students are inclined to incorporate the metacognitive control measures into their learning process.

Creating a meaningful learning experience through vocabulary instruction is one approach to expanding students' access to the linguistic requirements in a course and can contribute to an increased understanding of the material (Zukswert et al., 2019).

In this thesis, I conducted a case study which sought an instructional approach that was implemented in a classroom to aid students with their understanding of the required vocabulary and increase course performance. One researcher, Yin (2002) notes that a case study approach should be used when the researcher is asking a "how" or "why" question over a contemporary state of events over which the researcher has little or no control (p. 13). Yin additionally states that a case study does not have one single design, but rather the approach should be the most logical way of connecting the data to the study's research questions and conclusions i.e., using content analysis for verbal data. Wefer and Anderson (2008) used a qualitative content analysis when studying verbal data (interviews) of what information students were able to retain after a lesson. Qualitative analysis was used by Demirdogen (2016) in a case study in which verbal data was analysed to explore pedagogical content knowledge in instructors.

Statement of the Problem

This thesis explored one method that incorporates metacognitive instruction into a university science classroom through vocabulary instruction. The jargon present in a course can present a barrier to understanding concepts, which the EALBT endeavors to overcome. Therefore, students in introductory science classrooms could become more adept at learning course material. In the context of this thesis, I will demonstrate how metacognitive instruction was used as an instructional tool with the goal of vocabulary more successfully, so that they retain the knowledge longer and are able to use it for assessments or future courses.

Research Questions

For this thesis, I draw on a case study approach to identify the metacognitive aspects of the EALBT as they apply to explicit vocabulary instruction in a university zoology course in which the instructional approach has been implemented. The research questions that guided this study are:

1. How is the EALBT applied in an introductory university zoology class?
2. What - if any – and how are metacognitive aspects of instruction integrated into the EALBT?

To explore my first research question, I analysed the EALBT to better understand how this specific instructional tool was being applied in a classroom to promote students' lexicons, and the potential ways the method can be adapted. I investigated whether there was any variation that could be noted for how Professor Brown used this approach in his zoology course, exploring any differences in its format (e.g., if every case of the EALBT had classroom discussion). Adaptable instruction is a facet of effective instruction due to it encouraging student engagement and critical thinking (Darling-Hammond & Bransford, 2007). Differences in the format of the EALBT could additionally be beneficial for any instructors looking to use this methodology regardless of their different teaching styles. This first analysis explored the ways in which the EALBT can be implemented in the classroom, and the flexibility for its application.

To study my second research question, I explored how Professor Brown incorporates metacognition into a vocabulary instructional approach, and how course content (i.e., course vocabulary) was used to promote metacognition. Thomas (2012) in his research on metacognition considers its integration essential for science education which he states is due in part to the problem-solving students must undertake in science classes. He notes, however, how

the importance of metacognition is not always reflected in its prevalence in teaching practices found in science classrooms.

This study hopes to contribute to the existing body of literature on metacognitive strategy instruction in post-secondary science courses. Research has found that documenting and analyzing promising instructional practices can lead to an increase in adopting those practices across a faculty (Vu, 2017). As a result, through documenting the EALBT, access to the methodology is hoped to increase for when future instructors are looking to add a metacognitive instructional tool to their classes. This thesis additionally documents each metacognitive aspect of instruction found in Professor Brown's zoology course and demonstrates them as they are used in a classroom, which gives a clear path for future professors who would like to incorporate parts of (or the entirety) of this instructional approach.

Though an instructional tool could provide benefits for students, there are some barriers to integration on the part of an instructor (Sunal et al., 2001). One of the barriers includes insufficient instruction or knowledge on the instructional tool and its application in the classroom (Henderson & Dancy, 2007). Therefore, one goal of this thesis is to provide some knowledge on the application of the EALBT in a classroom to try and lessen the barrier to its use. This thesis explored how Professor Brown integrates the EALTB into classroom instruction. I looked at a range of cases focusing on factors such as the length of a case (one line vs multiple lines), the presence/absence of classroom interactions or the use of additional instructional forms (i.e., visual modes of instruction). Investigating the different approaches that could be used when applying the EALBT in a classroom could make it more accessible to future instructors.

Theoretical Perspective

The theory used to frame this paper is the Metacognitive Theory of Learning. Metacognition as a concept was originally presented by John Flavell (1976), who referred to it as “one’s knowledge concerning one’s own cognitive processes, or anything related to them” (p. 232). Flavell initially coined the term *metamemory* or *metathinking* and then later renamed it as *metacognition* to encompass the entirety of the cognitive process as an imperative for students to learn. He believed that through developing metacognitive skills a student may become increasingly independent and become self-taught (van Velzen, 2016), in charge of building their own knowledge and advancing their own learning.

Ann Brown (1980) an educational psychologist is another contributor who worked to develop metacognitive theory. She focused on the ways in which an instructor can teach literacy, and the positive effects that can have on students' metacognitive skills (Brown & Smiley, 1977). Her area of research focused on the ways in which students become better learners and how instructors can guide their students to aid them in this endeavor (Brown, 1980).

According to Flavell (1979), students' metacognitive skills can be described as belonging to two categories. The first category is *metacognitive knowledge*, which refers to what an individual knows about their own cognition or about cognition in general (Moshman, 2018). Flavell (1979) divided this category of metacognitive learning into the following three categories: knowledge of self, strategic knowledge, and task knowledge. Knowledge of self is what a student knows about themselves and their own thinking processes. Strategic knowledge is what a student knows about how a strategy works and how it may be applied. Task knowledge is what a student knows about how a specific task is to be done and which strategies would be applicable to that task.

The second metacognitive category, for Flavell (1979), was *metacognitive control* processes, which are the activities conducted by a learner to regulate their thinking and learning. This category includes planning, monitoring, and evaluating skills (Magno, 2010). Planning refers to a learner's ability to select effective strategies and allocates appropriate amounts of time to a strategy. Monitoring refers to an ability by the learner to be aware of their comprehension during a task and how they are performing on said task. Evaluation refers to a learner's ability to appraise the products of one's own learning and the process of how one achieved those products.

The metacognitive theory of learning postulates that, through practice and guidance, individuals can learn to control their cognition to become more effective at problem-solving and learning (Flavell, 1979). Social interactions, such as those that occur between students and teachers in a classroom, are pivotal for metacognitive development because they influence how a student perceives their learning (Reeve & Brown, 1985).

In sum, the metacognitive theory of learning integrates one's own knowledge about cognition and regulation of cognition into a systematic structure of knowledge (Schraw & Moshman, 1995), and is an extension of cognitivism or on the way in which individuals assimilate their understanding of the world and of themselves (Costall, 1987). Through a cognitive lens, behavior is the amalgamation of mental processes and events over which an

individual can exert some control. Cognitivists focus on learning processes and identifying the mental processes that they believe to be essential for human thinking and learning (Tani, 2016). Thus, metacognitive theory consolidates metacognitive knowledge and behaviour with explanations for that knowledge and behaviour (Flavell, 1979). That is, adds to cognitive theory by including the knowledge of how and why a task is being performed rather than simply the outcome of said task (Flavell, 1979).

Literature Review

To investigate a vocabulary instructional approach in an undergraduate zoology classroom and its connections with metacognitive aspects of instruction, I situated this thesis amongst previous studies. Therefore, I synthesized literature encompassing strategy instruction, vocabulary instruction, metacognitive skills, and morphemic vocabulary instructional approaches.

Vocabulary Instruction: Barriers and How They Can be overcome

Vocabulary contributes to precision, clear thinking, and communication in the classroom as well as access to course concepts (Krajcik & Sutherland, 2010). Students with a better understanding and ability to use course-related vocabulary demonstrate higher course concept development and performance (Radovan, 2019). Therefore, having a grasp on the vocabulary in a biology classroom is an essential part of a student's learning experience.

Vocabulary instruction in science classrooms is one means of potentially increasing scientific literacy in our students (Eitzel et al. 2017) which has been identified as a goal by science education researchers (Dillon, 2016). Scientific literacy is in part a person's ability to think scientifically or understand and be able to communicate scientific knowledge (Loughran et al., 2011). Norris and Philips (2003) identified 11 aspects to scientific literacy including the ability to think scientifically and the ability to use scientific knowledge in problem solving. The NSTA (1991) suggests there are upwards of 17 components to scientific literacy that can be separated into intellectual, attitudinal, societal and interdisciplinary categories. Increasing the understanding or ability to utilize scientific terms could therefore affect some aspects of scientific literacy in students and potentially contribute to their scientific understanding as a whole.

Biology Vocabulary: Barriers for Students

The understanding of biological terms is the building block upon which rests students' understanding of biology as a whole (Fisher et al., 2009). Schonborn and Bogeholz (2009) describe a hierarchical relationship for biological content. The biological term is the base of the hierarchy, because it conveys a limited piece of biological knowledge. The relationship between biological terms forms concepts, relationships between concepts form principles, and relationships between principles form biological fundamentals. For instance, to learn evolution, a student should understand the fundamentals of variation or selection, selection can be comprehended through a principle such as the development of land mobility, which occurred in *tetrapods* (*tetra* meaning four, *pod* meaning feet) which evolved in the taxa *sarcopterygii* (*sarco* meaning flesh, *pteron* meaning feather or fin). Therefore, it can be understood that these fleshy-finned fish developed feet to be four footed organisms, which helped them evolve to land mobility, which was an evolutionary advantage through selection. Through vocabulary instructional tools such as the EALBT, students can have an increased knowledge of their classroom vocabulary, and therefore may access Biology concepts with more ease both presently and in the future.

When compared to social science and arts disciplines, the language used in science disciplines tends to be more complex and lexically dense, which can lead to difficulties in understanding for students (Jalilifar et al., 2017). The complexity can stem, in part, due to the presence of Greek and Latin (among other languages) terms in the science disciplines, which may not be familiar languages to students in traditional western classrooms (Voultsiadou & Gkelis, 2005). Students may also have difficulties learning the material presented in science courses due to a lack of connection between their course material and their experiences outside of the classroom, including their cultural and language backgrounds (Young, 2005). Additionally, science vocabulary tends to be composed of low-frequency words, which are terms often unused outside of a scientific context, which decreases a student’s access to these terms due to their unfamiliarity (Lane et al., 2019; Zoski et al., 2018).

Comprehending and retaining course vocabulary can be challenging for students in university science courses (Shore et al., 2015). In the case of university biology classes, students have indicated that their curricula can be loaded with technical language, which leaves them feeling overwhelmed (Rivet & Krajcik. 2008). Understanding scientific language and being

taught the terms in an effective manner can therefore be important to help students move beyond memorization and into application and processing of vocabulary (Fisher et al., 2009).

Biology Vocabulary: Barriers for Instructors

An additional factor that adds to the potential difficulties with science vocabulary instruction is time constraints. Instructional practices which focus on vocabulary reduce the amount of class time that can be dedicated to pure conceptual development (Dehaan et al., 2005), therefore the large volume of terms that students are expected to learn in many biology courses forces instructors to choose which terms to instruct their students for maximum vocabulary development (Stahl & Clark, 1987). The limited time instructors can have to introduce vocabulary could contribute to the barriers students have to learning the terms if they are not given sufficient time to incorporate the knowledge.

The potentially limited pedagogical knowledge of university instructors could pose a potential barrier to the instruction of biology terminology (Brownell & Tanner, 2012). Professors who feel as though they have not been provided with enough pedagogical training to change their instructional styles tend to resort to those that were used to teach them as students (Brownell & Tanner, 2012). University instructors can adapt and change their teaching styles when given supports and the means to do so, guidance on fruitful instructional practices is key in assisting instructors.

Instructional Tools to Overcome Vocabulary Barriers

There have been ample studies on methods implemented in university settings to overcome barriers students face when learning science content (Wellington & Osborne, 2001). There is currently no overarching method that is demonstrably the best way to teach scientific vocabulary because the effectiveness of any given approach may vary based on student age, course work, and instructor style, amongst other factors (Boyd et al., 2012).

One method of vocabulary instruction has the instructor being explicit, that is being direct and clear about the meaning of a term (as opposed to being implicit, in which a learner should derive meaning from context) (Young-Davy, 2014). Explicit instruction should be implemented with contextualization, repetition, and meaning to increase students' access to classroom terminology (Harmon et al., 2005). Repetition as a learning tool can introduce vocabulary terms and their meaning into a student's working memory. Once there, the vocabulary terms and their meaning can then be potentially transported into the long-term memory (Larsen-Freeman, 2012).

McDonnell et al. (2016) used a concept-first-vocabulary-second method to teach entry-level university students. Course-specific jargon was removed from initial readings and lessons, and later re-integrated. Their study found increased indicators of conceptual understanding when colloquial language was used to describe course content. This study demonstrated that while allowing for conceptual understanding a classroom devoid of jargon hinders a student's ability to incorporate classroom terminology into their working vocabulary, therefore impeding their overall understanding of the classroom material (Brown & Ryoo, 2008). However, science instruction without incorporating scientific lexicon, although useful in the short-term, may pose barriers for students and limit conceptual understanding in the long term (Brown, 2004).

Aspects of Effective Instruction

There are psychological tools that an instructor can use to increase the effectiveness of their instruction. Vygotsky (1978) proposed the idea that effective instructors remain in their students Zone of Proximal Development [ZPD], which he described as an area of learning at which content is neither too familiar nor too alien. Students who are learning in their ZPD will find the content engaging as it is not too challenging in which they do not understand any part of a lesson and not too simple as to make the students too bored to engage with the lesson. However, finding the ZPD for each individual student in a university course with over 150 students could pose a challenge for university instructors.

Additional psychological tools a teacher can use to be effective include clarity (in instruction and feedback) and immediacy (student perception of the warmth of their relationship with the instructor) (Bolkan et al., 2016). Rosenshire & Furst (1973) suggested five teacher characteristics that are associated with a gain in student achievement in a classroom. These five characteristics are: enthusiasm, businesslike orientation, teacher clarification (avoiding vague words, answering clarification questions promptly), variety in instructional approaches and providing opportunities to learn curriculum content.

When an instructor is effective in classroom communication and clarity it can indicate towards increases in student understanding of concepts, however, this thesis focuses on one instructional tool, the EALBT. Therefore, I analysed what can make an instructional tool – not the instructor - effective.

Communication for Effective Instruction

In addition to psychological tools, effective instructional strategies include factors such as communication, positive classroom environments and an involved instructor (Marzano, 2007). Of the factors mentioned, proper communication between a teacher and their students is an important tool for instruction and one that is pertinent for the EALBT (Bambaeeroo & Shokrpour, 2017). In order to use the EALBT an instructor should be able to communicate in verbal and non-verbal ways due to the instructional approach revolving around defining terms and conveying that to students.

To communicate effectively in a verbal form, instructors should speak clearly and eloquently using words their students will understand (Bambaeeroo & Shokrpour, 2017). Non-verbal communication can be a more subtle but potentially more powerful form of communication because it could convey meaning more efficiently than words (Bambaeeroo & Shokrpour, 2017). Non-verbal communication ranges from tone to body language or facial expressions and can be used to convey emotional information (i.e., excitement) or to decrease physical barriers (i.e., relaxed body language can make students more comfortable and therefore more receptive to instruction) (Conley, 2019). Both verbal and non-verbal communication can affect a student's reception of information in the classroom.

Strategies for Effective Instruction

In addition to effective communication, instructors can also help their students understand the course content by making them aware of how and why a strategy is being implemented (Kupermintz, 2003). Effective instructional strategies are often flexible because they allow for variation that accommodates different teaching styles and classroom environments (Loughland, 2019) to address student's needs.

Research has determined that an increase in available knowledge of instructional strategies increases the adoption rates for teachers (Brownell & Tanner, 2012). Cole (2012) introduces the idea of the "funnel of professional learning transference" (pp. 109) which begins with an instructor being introduced to a new practice, receiving training, trying it out and reflecting on how to improve its implementation in their classroom. Therefore, studies such as this one holds an important role in introducing instructors to a teaching practice, they could find useful, and give indications as to how they could use it, however providing a description and examples of the instructional approach is additionally useful.

Scott (2016) examined instructional strategies that increased student performance and he found common components. These commonalities include connecting past and present material, modelling, providing multiple repetitions for success and providing students with consistent feedback. Effective instruction can also be implemented in a classroom to combat a weakness recognized by an instructor (Scott, 2016). For my research, the EALBT is meant to address difficulties students have in zoology with their classroom vocabulary as perceived by their instructor.

EALBT and Morphemic Methods for Biological Vocabulary Instruction

Learning science concepts requires an understanding of vocabulary; however, knowledge of scientific vocabulary does not inherently translate to the ability to use vocabulary terms (Townsend et al., 2018). The EALBT encourages understanding of not only the definition of a term, but also the structural role of a word (Brown, 2014) which encourages contextualized learning and meaningful connections between terms (Brown & Ryoo, 2008). As a result, the EALBT can promote conceptual understanding while promoting terminology acquisition.

When using the EALBT, a vocabulary term is deconstructed and defined to promote connections between known and novel terms. The EALBT introduces the morphemes of a term which are the smallest meaning bearing unit, in oral or written language (Kirby & Bower, 2017). These units include suffixes, prefixes, and root units of the terms, which are then taught to students. While teaching the morphemes, a professor can make etymological connections with other terms due to a shared root unit, describing how the words relate to each other.

Teaching root words, prefixes, and suffixes has been found to increase students' abilities to infer the meaning of a term (Baumann et al. 2003). This strategy is implemented to create relevant connections between vocabulary terms and their definitions, which endeavor to move beyond memorization and into understanding and utilizing said terms (Zoski et al. 2018). However, one drawback to morphological instruction is a teacher's potential lack of knowledge for morpheme instruction or the morphemes themselves (Washburn et al., 2011).

Providing etymological information to students could additionally reduce any potential confusion from false cognates, which are two terms that appear to be related, however they do not share etymological histories. An example of a false cognate would be *attend* (Eng. meaning: to be present at) compared to *attendre* (Fr. meaning: to wait for), therefore giving students etymological information could cue them to the meaning of a term and reduce confusion.

Therefore, the EALBT could contribute to students' comprehension of vocabulary in science classes (Quigley, 2019). This research paper examined one morphological instructional approach and how it was incorporated into a classroom.

The EALBT for Biology and Zoology

In their paper, Zukswert et al., (2019) researched students perceived and actual understanding of biological terminology in an undergraduate classroom. They found that there were terms that were not understood by students despite being used multiple times during class by the professor. Therefore, there is more than simple use of a term in a classroom to give students the ability to understand and utilize said terms. The use of instructional approaches such as the EALBT are meant to bridge that disconnect between use in class and understanding of terminology.

Students in biology courses are prone to terminology overload because its terms are long, polysyllabic, and generally complex, all of which can lead to students feeling overwhelmed (Krajcik & Sutherland, 2010). Biology courses can also have low-frequency terms, meaning they are not often encountered by students outside of the classroom (Zoski et al., 2018). The morphemes composing these terms are generally of much higher frequency – lending to the usefulness of a morphemic focused instructional tool (such as the EALBT) (Carlisle & Stone, 2005). Zoology, as in many of the life science and biology subjects, contains long polysyllabic terms due to the use of binomial nomenclature for animal classification purposes.

Zoology has a mandatory nomenclature guideline, the International Code for Zoological Nomenclature (ICZN) (Ride, 1999). Although not a strict requirement of the ICZN, many zoologists have used descriptive or meaningful ancient Greek or Latin roots when naming organisms (Voulstiadou & Gkelis, 2005). This system can lead to some necessary complexity in zoological names which can be overcome using morphological tools such as the EALBT.

Metacognitive Aspects of Teaching and Learning

In addition to the previously discussed aspects of effective instruction, metacognitive instruction can be beneficial for students. Metacognition is instrumental for situations in which students encounter a problem they do not know how to solve. A student with high-level metacognitive skills should be able to choose an appropriate strategy that would guide them towards the solution (Holton & Clarke, 2006). In higher education courses, students with higher levels of self-regulated learning skills generally achieve better outcomes than students with fewer

skills; therefore, self-regulated learning becomes increasingly important in university courses (Bail et al. 2008).

Instructing Metacognition

Instructors can support and develop their students' metacognitive skills using metacognitive strategy instruction. Ellis et al. (2014) detailed facets for strategies that promote the metacognitive skills of students. These facets include: engaging course curriculum, where students have many opportunities to actively learn and use their metacognitive thinking skills due to students interest; assessment integration, which stipulates that information that is important to instructors will be noticed and learned by students; consistent practice, in which instructors give students the opportunity to use their metacognitive skills; explicit strategy instruction, where an instructor is direct about the why and the how to use a metacognitive skill; and verbalizations, in which instructors model behaviors and describe their thinking processes aloud. The desired outcome for the instruction of a strategy with metacognitive goals is to increase the metacognitive knowledge of students in the classroom (Moshman, 2018).

Papaleontiou-Louca (2003) also compiled a list of instructor strategies that can be used to develop the metacognitive abilities of students. The strategies include focusing a student's attention on the problem they must solve, encouraging students to generate questions throughout instruction and helping students form connections in the material. Each of the previously mentioned strategies, when applied in a classroom, can potentially work to increase a student's metacognitive abilities.

Strategies and practices which enhance metacognitive skills can result in increased student goal achievement and task completion (Hartman, 2001). Metacognitive instructional strategies can guide students to increase their self-regulated learning habits (Pintrich, 2002). The use of metacognitive strategies has a positive impact for students, and it is important to understand the ways in which an instructor can influence metacognition (Alias & Sulaiman, 2017; Mariano et al., 2017) to increase adoption of new methodologies and encourage pedagogical change (Quigley et al., 2018). Therefore, instructors must be given tools to adopt metacognitive instructional strategies, such as workshops, explicit instruction, or models to follow (Harmon, 2005).

When using metacognitive instructional strategies in undergraduate science courses, certain metacognitive interventions use supplementary questions or assessments that do not

necessarily have any relevance for the course content. For instance, Colthorpe et al., (2018) used a series of questions regarding students' goals and expectations to stimulate metacognition. For this study, I analyzed the metacognitive strategies used in conjunction with the EALBT. I will not only provide an analysis of the ways in which metacognitive strategies can be used in conjunction with a teaching methodology, but additionally supply an explicit description of these connections to provide guidelines for future professors wishing to integrate this instructional approach into their classrooms.

Benefits for Instructors

Metacognition is an important tool for instructors as it can influence student learning outcomes (Askell-William et al., 2012). If an instructor is knowledgeable about metacognition and teach it to their students, they can experience an increase in learning gains (Hartman, 2001). There is a format of metacognitive instruction which is called the metacognitive intervention. In this case, students must perform short reflective writing tasks twice per week. They also are questioned about what they believe to be important in the classroom, and what they did or did not understand. One study by Askell-William et al. (2012) found an increase in student metacognition, however they additionally found that instructors continued to use metacognitive instructional strategies after the study was completed and taught their colleagues how to use the strategies as well. Therefore, instructors can be open to adding metacognitive practices in their classroom, however they must be given tools and guidelines as to how to implement them.

This approach could be seen as time consuming and take away from the time needed for class content. Approaches such as the EALBT could therefore have the benefits of a metacognitive instructional strategy while not taking too much time away from course content. When using the EALBT, an instructor does not need to take 5 or 10 minutes before or after a lesson to have students write down their thoughts or discuss with classmates. Therefore, teaching instructors a metacognitive instructional tool such as the EALBT could increase adoption rates due to the lesser time constraints.

Metacognitive instructional strategies can work by focusing attention on key content information that students must learn to succeed in a course, a key step in knowledge acquisition (Anderson, 2011). A metacognitive strategy should be built to prompt students to focus on important ideas of a lesson, the EALBT explicitly directs students to their classroom vocabulary so that they can understand and utilize the terms. A metacognitive strategy could additionally

relate past and present information to create connections in the material (Weinstein & Mayer, 1983).

Methods

In order to describe the use of the EALBT in a zoology classroom, as well as detail how an instructor can incorporate metacognitive aspects of instruction into a vocabulary instructional tool, I used a qualitative case study approach. A case study approach was used to provide an intensive explanation of how this approach is used by an instructor. Although there is only one instructor known to be using the EALBT, the nuances of the EALBT were more easily described by a case study. The case study centered around one zoology instructor at the University of Ottawa, who had developed the EALBT to be used in their courses. The instructor for this thesis was chosen as it was known that they used this instructional approach, in addition they were a supervisor for this study.

There was a total of four analyses used for this thesis, the first three used the same data for the EALBT analysis, the fourth analysis used a second set of data for the word list and therefore had its own methodology for data collection.

Establishing a Case Study

One goal of this thesis was to thoroughly explore the EALBT as it is used in a classroom and to document its use. Experimental approaches to document the EALBT were considered, including comparing the approach documented in this case study with other morphemic approaches used in science classrooms. A secondary experimental approach of introducing the EALBT into a classroom and comparing test scores to previous years was additionally considered. Due to complications that arose from the COVID-19 pandemic and classrooms moving to online learning compounded with the goal of this thesis to focus on the EALBT and detailing the teaching method as it is used, the best approach was determined to be an observational case study. In addition to the goal of thorough documentation of the EALBT, the instructor observed for this case study is the only one currently known to be using this instructional method which was further justification in establishing this thesis as a case study.

Case studies are generally viewed as a less rigid approach to research when compared to experimental research (Yin, 2002), they investigate one subject or one case in an intensive manner rather than generalizing across multiple subjects. A case study as a research method for

educational research has multiple approaches. Researchers have varying opinions on the structure needed for a case study.

According to Yin (2002) there are four important components (and one optional component) that should be found in every case study. These components are, the questions, the propositions (if there are any), the units of analysis, the logic linking the data to the propositions/questions, and the criteria for interpreting the findings. The fourth and fifth components hold more weight and should be determined before conducting the study as they refer to the data collection and analysis. Analysis should be rigid and predetermined and from Yin's perspective, minor changes can occur during the study, however if any major changes are necessary, the study should be redesigned from the beginning. For my thesis, I used a research approach that would codify verbal data to increase the validity of the findings, this approach was predetermined and implemented as designed following my data collection.

Ethical Approval Process (File Number S-12-21-7546)

Before accessing any data for this thesis, I began with the ethics approval process. The university of Ottawa requires an ethics approval for primary use data (collected by researcher for the purpose of the study) or secondary use data (collected previously and used by researcher for a new purpose). My thesis used in-class videos that had been captured to be used as study material for the students in the course. The students in the course would have access to the videos and be able to rewatch them to prepare for their examinations. My study was therefore classified as a secondary use data, and I submitted the ethical approval as such. Each video centered on the instructor at the front of the course, and therefore he was a potentially identifiable individual, which requires ethical approval and the consent of the individual involved. As a part of my approval process, the consent provided by the professor, as well as access to the videos were identified.

The ethics approval process included filling out the necessary forms on the online portal through the university of Ottawa student online services and submitting the form to be reviewed and approved. Once I received an approval to continue with my research, I began the process of collecting and analysing my data.

Collecting EALBT Data

I collected data from one semester of instruction of a second-year zoology course, *Animal Form and Function,* taught by Professor Brown at the University of Ottawa, who provided the

recordings of his classes. They were recorded using the ECHO-360 in-class lecture-capture and feature a view of the professor at the podium in front of the lecture hall. Twenty-one videos were available, however three contained no class material (two were from midterms, one was of an empty classroom) and therefore 18 class videos remained.

Before watching through all 18 class videos, I first needed to define the parameters of the EALBT. These parameters ensure that when collecting my data all cases of the EALBT were noted and transcribed. Prior to watching the class videos, the EALBT was initially defined using Professor Brown's 2014 paper, in which he explained the objective of the etymological approach to be to "aid students to incorporate new words into their personal lexicons by matching root morphemes to those already existing in their repertoires and making inferences about the terms' meanings from their etymologies"(pp. 1). Therefore, I looked for any classroom interactions that included the explanation of one or more morphemes of a term. That is, for a section of a lesson to be counted as an instance of the EALBT, I had to observe Professor Brown presenting the morpheme(s) for a term and the meaning of the morpheme(s). For instance, if Professor Brown were to define an Arthropod as "an invertebrate animal with jointed appendages", that would not be counted as an instance of the EALBT. If Professor Brown were to instead say "Arthropod, *arthro* meaning joints, and *podus* meaning feet, is an invertebrate animal with jointed appendages", I would count that as an instance of the EALBT. Each instance began with the introduction of the term in question and end with Professor Brown "wrapping up" or moving onto another piece of course content.

However, there was one exception to what could be counted as a case of the EALBT due to the terms themselves: the unbounded morphemic words, also known colloquially as single morpheme terms. These are words that are made up of one singular morpheme. For instance, the word *pharynx* is its own morpheme and has no parts. When presenting that word to a class a professor would not necessarily need to say, "*pharynx* that is made up of *pharynx*", for it to be considered an instance of the EALBT, however, it could be explained. Therefore, if Professor Brown were to introduce the term *pharynx* to his class and explain how the term derives from Latin origins or how it relates to other terms such as *suprapharyngeal*, I would still count this as a case of the EALBT without necessarily needing to identify its singular morpheme.

I began the data collection process by watching an entire semester's worth of class sessions (excluding videos that do not contain any class content). From these videos, I conducted

maximum variation purposive sampling to select class videos that were representative of the instructional approach. Purposive sampling is an approach in which a non-probability sample is selected based on the characteristics to be studied. The approach is generally used in qualitative research to identify information-rich instances related to the study and research questions (Patton, 2002). Maximum variation purposeful sampling selects cases based on norms found in the dataset, and cases that vary from the norm to document the diversity of the chosen phenomena and to identify patterns across variations (Palinkas et al., 2015).

The phenomena documented in this case was the EALBT. When starting the purposive sampling, I made the decision to choose full classes (a video comprising an entire class session) to analyse, rather than simply pick out interesting cases from individual videos. Purposive sampling is used to analyse the norm, and the abnormal cases found in a dataset (Palinkas et al., 2015). For this thesis, to ensure a large range of abnormal and normal cases, I chose classes that had at least one "extreme" case and documented every case of the EALBT found in that class. In order to find and document the "extreme" cases, I had to explore what would make a case extreme. After my initial watch through it became clear that not every case of the EALBT had student interaction, and therefore this represented one extreme (the presence of teacher-student interactions). There were additionally some cases that only encompassed one or two lines of dialogue and therefore were very short, to contrast there were some much longer cases that went into more detail. Once I found a class that had a detailed or interactive case of the EALBT, I searched to see if this class had any other cases of the EALBT (to document the "norm"), if it did not, I did not include it in my dataset. Therefore, to be included in my dataset, a class needed at least two cases of the EALBT, one of which needed to contain detail (longer than one or two lines of dialogue) or classroom interaction.

Through the purposive sampling process, I chose Class 2, Class 6, Class 9, Class 15, Class 18, Class 20, and the introductory class. The intro class has data that will be used to document, explain and introduce the EALBT, however it will not be used for the metacognitive or statistical analysis as there was only one case of the EALBT found in this class

Table 1

Cases of the EALBT collected across the dataset in each of the classes transcribed

Class 2	*Sarcoplasm* *Binomial nomenclature* *Polyphyletic*

	Cephalization *Gastrulation* *Diploblastic* *Acoelomate/pseudocoelomate*
Class 6	*Monoecious* *Gonozoid* *Thicate* *Platyhelminthes* *Lophotrochozoa* *Protonephron*
Class 9	*Spermatophore* *Hemocyanin* *Annelids* *Polychaeta* *Notapod*
Class 15	*Protopodite* *Lepidoptera* *Parasitoid*
Class 18	*Enteropneusta* *Pterobranchia* *Urochordata*
Class 20	*Amphibian* *Gymnophiona* *Caudata/Anura*

From Table 1 we can see the distribution of terms across the dataset. Each class had at least 3 cases of the EALBT, which satisfied the parameters I set for my purposive sampling. Three of the classes had higher numbers of cases, Class 9 with 5 cases, Class 6 with 6 cases and Class 2 with 7 cases. Therefore, I had 27 cases of the EALBT to use for my analysis.

There are two cases of the EALBT that broke down two related words. In class 6, when introducing the term *acoelomate*, Professor Brown additionally introduces and explains the term *pseudocoelomate,* due to them sharing the morpheme *-coel*. I counted these instances as one case of the EALBT due to the parameters I initially set for when a case begins, and when it ends. Professor Brown had not wrapped up the case of the EALBT for *acoelomate* before introducing *pseudocoelomate* and only wrapped up after explaining both. The second case that had two words included was found in Class 20, in which Professor Brown explains both *caudata* and *Anura* to his class. Once again, these are related terms, with both *caudal-* and *-ura* meaning tail in different originating languages (Greek and Latin).

Procedures For Analysis of EALBT Data

Three analyses used this first set of EALBT data. The first two analyses used a qualitative content analysis approach. Qualitative content analysis is a method used on qualitative data in order to quantify it and categorize it based on themes or patterns found throughout a dataset. According to the procedures used for this study as laid out by Elo and Kyngas (2008) there are two approaches to qualitative content analysis. The first approach is inductive, in which there is no previously collected data on the phenomena that will be researched, and therefore the researcher must create a categorization matrix of their own while conducting the study. The second approach is deductive, in which there is previous research on the phenomena to be studied and therefore the researcher can create (or find) a categorization matrix before conducting the study. The third analysis was a statistical analysis, which used the results from the previous two studies.

Methods to analyse the EALBT facets

In order to analyse the different forms of the EALBT I used an inductive approach which contains three phases. The first phase is the preparation phase in which a unit of analysis is chosen, this unit can range from a single word to an entire interview. In my case, I have chosen cases of the EALBT as my unit of analysis. I transcribed the 27 cases of the EALBT found in the courses using the parameters I had outlined to start and end the transcription of each case. My transcriptions included the instruction given by Professor Brown, actions that occurred in class and any classroom interaction that could be heard, as student responses were all unintelligible, they were represented by "(class murmur)". I additionally transcribed relevant information including gestures or an indication of the instructor writing on a chalkboard, from the introductory class where the EALBT was introduced and explained to students.

The second phase is the organization phase, in which I searched for codes in the dataset. To code my dataset, I began by printing my transcriptions for each class and reading them all through. In my first read-through, I wrote notes in the margin regarding what was occurring during each case, focussing on what Professor Brown was doing. I then searched for patterns in the notes I had collected, I found some distinguishing features between cases. For example, after the first pass-through of the cases of the EALBT, there were some that included classroom interactions and some that did not. Once my second pass-through had been completed, I named

these differences the facets and the sub-facets of the EALBT. Each facet that can be used for the EALBT will be explained further below in Table 2.

Table 2

Name and Description of each Facet and Sub-Facet of the EALBT found through a Qualitative Content Analysis

		Description
Facet	Explanatory	Verbally explaining the meaning of morphemes
	Call and response	Asking students questions to identify root terms
	Replacement word	Introducing additional terms to explain the initial term
Sub-facets	Colloquial	Using lay terms to explain root terms
	Visual	Visually introducing or explaining terms

While analysing the EALBT, I found 5 categories. Three facets, and two sub-facets. I categorized a facet as a main means of using the EALBT, one that could exist independently. Sub-facets did not exist on their own but were supplementary to the facets. Visual and colloquial sub-facets were not found to exist independently and therefore do not fall into the same category as the "explanatory", "replacement term" or "call and response" facets. Multiple facets and sub-facets can be used during a sole case. For example, there was one case of the EALBT that used "visual", "call and response" as well as a "replacement word" approaches to the EALBT.

Methods to analyse metacognitive aspects of instruction in the EALBT

Metacognition has been described as a "fuzzy" concept; it can be difficult to measure as well as challenging to know when students are learning metacognitive skills (Hartman, 2001). Therefore, to explore the metacognition that could be found in the EALBT, I conducted a second qualitative content analysis. The second analysis was based upon the deductive analysis as outlined by Elo and Kyngas (2008). Phase one for a deductive approach is the same as with an inductive approach, in which the researcher needs to identify the unit of analysis (cases of the EALBT). In phase two, I compiled studies in which a metacognitive intervention was applied by the researchers, and they found a positive effect on the metacognitive abilities of students. These studies generally use student self-report data or tests to measure when students could be developing metacognitive skills. Using the research gave me the categorization matrix from which I could identify metacognitive instruction within the EALBT accurately. The table is compiled from research as outlined by Ellis et al. (2014), Papaleontiou-Louca (2003), and the

Education Endowment Fund (EEF) (Quigley et al., 2018). In Table 4 I have collected a list of instructor approaches that can have an influence on the metacognitive abilities of students, which have been labeled metacognitive aspects of instruction. Students can have differing levels of metacognitive ability, and students can gain metacognitive abilities (Hartman, 2001).

Table 3

Metacognitive Aspects of Instruction as Outlined by Ellis et al. (2014) in "An Analysis of Research on Metacognitive Teaching Strategies", Papaleontiou-Louca (2003) in "The Concept and Instruction of Metacognition" and EEF (Quigley et al., 2018) in "Metacognition and Self-regulated Learning"

Metacognitive Aspects of Instruction	
Engaging curriculum	Orient learning for deep understanding and provide opportunities for metacognitive skills (Leutwyler, 2009) Problem-based learning, concept teaching (Haidar & Al Naqabi, 2008)
Assessment integration	Instruct to enable students to become aware of the criteria for assessment (Koutselini, 1995)
Consistent practice	Use strategies across multiple lesson for tangible gains (Scharlach, 2008)
Explicit strategy instruction	Modelling a strategy while explaining why it is effective, verbalizing thoughts while modelling (Kistner et al., 2010) Direct instruction, modelling, explaining benefits, provide repeat opportunities (Scharlach, 2008) Guiding student choices, and exploring consequences (Papaleontiou-Louca, 2003)
Verbalizing	A part of explicit strategy instruction, thinking aloud and explaining a strategy (Scharlach, 2008) Internal and external self-talk is encouraged (Haidar & Al, Naqabi, 2008) Encouraging students to think aloud (Koutselini, 1995)
Thought Process	Generating questions through prompts (Papaleontiou-Louca, 2003) Focus a student's attention on the way they think and problems they must solve (Koutselini, 1991) Ask students to identify what they know and what they do not (Papaleontiou-Louca, 2003) Activating prior knowledge to incorporate new information (Quigley et al., 2018)

There could be some potential overlap between these different metacognitive aspects of learning. For instance, an important aspect of explicit strategy instruction is the verbalization of thought process, however verbalizing thought processes is its own category, as a professor can verbalize a thought process that would not be explicit strategy instruction.

Methods for statistical analysis

Using the data collected from the first two analyses I conducted some statistical tests. I used SPSS, a statistical program available to University of Ottawa Education students in the research library. Firstly, I found the mean instances of the metacognitive aspects of instruction for each facet of the EALBT. I then did an ANOVA on those means to test for a significant difference among the means of the test groups ($\alpha<0.05$). The ANOVA was chosen as the data collected was for multiple independent groups (the facets of the EALBT). After conducting the ANOVA, a statistical difference was found to exist, and therefore I conducted pairwise comparisons between each of the facets of the EALBT to determine where the significant differences lie.

Data collection for the word list analysis

Three websites were used to find the etymology of the terms as not every term could be found in the same location. Etymology Online, followed by Biology Online and finally if neither of those contained the etymology of the terms, I used, Merriam-Webster dictionary. Some of the terms in the word list contained items that could not be found in any of the mentioned online dictionaries, for these cases words similar terms (i.e., Singular or plural terms) were used to find root etymologies. For example, the term *hematophagy* could not be found, however *hematophagous* could be found and I extrapolated from that term. Furthermore, there were terms that could not be found entirely in any of the mentioned dictionaries for instance *ichthyostega.* This term could not be found in its entirety, however when broken down into its morphemes (*ichthyo* + *stega*), I could find it on Etymology Online. From previous terms such as *chondrichthyes,* I know there is a morpheme *ichthyo* and in Etymology Online, I found the morpheme *stega.* Therefore, the etymological roots were put together using the information from the morphemes. There were terms found that did not have consistent etymologies as words can evolve over time. For instance, if we are to look at the etymology for the term *pedicel,* etymology online would say the root for this term comes from the Latin *-pes* which derived from the Proto-Indo-European [PIE] root *ped.* However, if we were instead to look at a term such as

cephalopod this is a Greek term that has a root unit *pous*, however this Greek unit also derived from the PIE root *ped.* Therefore, there is a choice between the Latin/Greek roots, or the older PIE root for every term that contains one or the other.

When constructing my list, I stayed consistent with etymology roots and shared history. Therefore, for *cephalopod, cephalo* has Greek roots, and therefore I used the Greek term *pod*. *Pedicel* derives from the Latin term *pedicellus* and so I used the root term *ped*. Part of the process of the EALBT includes finding the etymological connections between terms and using that to discover meaning. The two languages from which most scientific terminology is derived (Latin and Greek) have a distinction between roots and therefore teaching the connections will indicate the etymological history and could additionally ease confusion. The instructor studied for this thesis mentions a similar connection between two terms that do not have shared histories. He explained the meaning of *ura* as well as *caudal, both* of which mean "tail" in their respective languages of origin. Therefore, I constructed the etymological roots in such a way that an instructor using this list would give etymological hints to their students.

Methods for the Word list analysis

Professor Brown provides a list of terms for each of the topics that he will cover over the course of the semester. This list comprises terms he believes students should understand to be successful in the course. There was a total of 18 topics, and 18 vocabulary lists, which enumerated a total of 2027 terms. I compiled these terms into a master list. When compiling this master list there were a few modifications that needed to be made. Firstly, I deleted all repeated terms. If an exact term was present more than once in the master list, it was deleted. For example, the exact term *pharynx* appears nine times in the 2027 terms. When putting together the master list, I deleted eight of those nine instances of the term pharynx. However, there were exceptions made for occurrences of a term that were not exact replicas. To continue with *pharynx,* I kept terms such as *hypopharynx* or *suprapharyngeal* as those are not exact replica (and indeed are completely different terms with a shared morpheme) but I also kept term such as *pharynx sheath* or *muscular pharynx* as those were counted as separate terms from *pharynx* alone. Therefore, the parameters to delete terms in this case was straightforward. If two terms in my master list were identical, replicas were deleted until there was only one instance of each term.

The second modification I made was for items in the list that were not deemed to be terms, but instead were phrases. For instance, in the first topic list, there is an entry that reads "1.5m species known and described", I did not include this as a term for my master list as it is a phrase, rather than a scientific term. The parameters for inclusion or deletion of phrases had to do firstly with the addition of prepositions. Therefore, phrases such as "ions flux and osmotic gradient" or "toes as a lever" were not kept in the dataset. I additionally made an exclusionary parameter for phrases that did not include scientific jargon for instance, "increase surface area," "increasing offspring survivorship," or "swallow with the eyes," that although may be describing a function of an organism, could reasonably be described as non-scientific and free of jargon. This parameter came into effect, as one of the purposes of the EALBT is to introduce unfamiliar terms to students. Therefore, it is reasonable to assume "increase surface area" would not be included however if we were to compare that to "aposematic colouration" that has terms that would be considered jargon that would be included in my master list.

This condensed master list is 1140 terms. I then researched to find a list of the etymological morphemes attributable for each term. I compiled the etymological roots to determine any connections between terms. For instance, *parapodia*, *protopodite* and *neuropod*, all have the same root morpheme of *pod.* If students were strictly tasked with finding morphemes, the second morpheme in each of these terms would look slightly different (*podia, podite*, *pod*). When investigating this list, finding the etymological roots of the terms, aided in finding connections between terms, and their shared roots. The entire master list, along with their etymological roots can be found in Appendix A.

Analysis of the EALBT

In order to determine the metacognitive aspects of the EALBT, I conducted an initial analysis of the instructional approach itself. This initial analysis was used to determine any differences that could be found in the methodology so that I could then examine if these changes in the instructional approach were accompanied by any variance in metacognitive instruction.

Purpose of the EALBT in a University Zoology Course

The purpose of the EALTB as defined by Professor Brown during his class is to give students increased access to their terminology to be able to use them in classes rather than simply know their definitions. From the introductory class Professor Brown establishes the use of this methodology and mentions:

> So, I'm going to be teaching this course using an etymological approach in order to allow you to not have to memorize any of these terms because once you understand how these terms are built, you will be able to acknowledge the meaning and from now on you'll never have to memorize anything, any of them (Class 1).

From this explanation, it can be understood how Professor Brown introduces novel terms to students for them to have access to the meaning of the term and to be able to utilize the term in the future. Bloom's taxonomy indicates that students should be expected to move beyond a surface level accessibility of a concept into a deeper level of understanding and utilization (Bloom, 1956).

Further into Class 1, Professor Brown elaborates on his reasoning for the instructional approach, "[w]e're talking about possibly hundreds of new terms that need to be known, understood, explained and defined. I have a way for us to learn this without having to do all that" (Class 1). Therefore, it is not solely the potential complexity of the terms that founded this methodology, it is additionally the number of terms that seem to have prompted Professor Brown to formulate this instructional approach for his students. Professor Brown is communicating to his students that with the vocabulary instructional approach he is proposing, they would not need to be concerned with memorizing a multitude of new terms, but rather they could learn them more efficiently. To give some further insight to students regarding the purpose behind this methodology, Professor Brown gives more reasoning in Class 2:

> Particularly in science, names have meaning. As we have seen, the scientific language is built from units of meaning and so the words that we give to organisms and to groups of organisms and traits are actually reflective of what they do which is why this etymological approach to understanding terminology will be so important as a tool for us to be able to recognize this, but another thing that is inherent to the naming system of science is that it also describes the evolutionary relationship between organisms. (Class 2)

From this passage, we can extrapolate that there is a connection between a scientific term and its meaning, which would make an instructional approach such as the EALBT appropriate for this course. Professor Brown relates that the roots to terms in zoology can describe the form or the function of an organism or a piece of an organism and therefore there will be conceptual benefits to the students when they understand the meaning of the term. In this section, I will be

examining what defines this instructional tool and whether there are different ways in which it is used by Professor Brown.

Examples of the Facets

In order to explain what each facet looks like, and how they are used in this zoology classroom, I will provide an example of each one and describe what is occurring in the classroom for each. Although these facets can be interwoven and stacked, each one is still easily identifiable.

Explanatory

The explanatory facet is the one that is the most straightforward of the three found in my dataset. To use this form, an instructor would need to meet the basic parameters that I laid out for the EALBT (presenting morphemes and explain their meaning to the students). This facet could be considered as the "basic" approach to the EALBT, where the other four facets could be described to add on to the explanatory form (through the addition of questions or a visual means of instruction for example). In Class 2, I observed an explanatory form of the EALBT when Professor Brown was introducing the term *diploblastic*, he explains,

> And this is also known as a diploblastic body plan, *diplo* meaning two, *blast* referring to the embryonic germ layer of tissue, so there's only two in the more simple tissue composed animals, they're *diploblastic* because they only have endoderm and mesoderm. (Class 2)

As we see here, Professor Brown introduced the term to his students in two sentences. He verbally explained what each of the morphemes means to his students as a means of easing access to the word, however it does not necessarily go into detail as we might see with some of the other facets. The example provided identifies an easily integrated instance of the EALBT, that does not necessarily require much time or additional knowledge for an instructor.

Colloquial

There were cases in which Professor Brown used simple straightforward language to explain a term as an addition onto his explanation of the morphemes. As an example of colloquialisms being used to explain a term to the class, is seen in class 15, when Professor Brown introduces the term *protopodite.* He explains, "that basal segment is the *protopodite* meaning the first aspect of the little leg, *podite* meaning 'little leg' and *proto* meaning 'the first' and so the point at which it attaches to the body is the *protopodite*" (Case 15). In this case,

Professor Brown uses both an explanatory approach to this case and a colloquial description of it. When Professor Brown is introducing the term, he says "the first aspect of the little leg" which is in plain language. If we were to look at a dictionary definition for *protopodite* it would read "the basal part of a typical limb of a crustacean consisting of two more or less consolidated segments and bearing at its distal extremity an exopodite or endopodite or both." (Merriam-Webster, n.d.) There is a difference in the complexity between these two definitions, and how potentially students can understand them. Jargon-free explanations, or those that reduce jargon, make content more accessible for students (Brown & Ryoo, 2008), therefore we can see how this explanation could ease access to this term both by breaking it down, and using everyday terms.

Call and Response

A "call and response" facet of the EALBT refers to those that contained some form of classroom interaction during the explanation of the term, generally of non-rhetorical questions. Questions that occur during a case of the EALBT and are unrelated to the term being described would not qualify as a case of call and response; for example, "did you have a good weekend?". From Class 18 we can see an example of a call and response approach to the EALBT when he introduces the term *pterobranchia* to his students:

> So, that is it so let's move on to the second class within our phylum *hemichordata*, class *pterobranchia*, in which we have ptero branchia being the root words and we know these root words already. What is a *pteron*? Someone say it please out loud? (Class murmur) A wing! And *branchia* refers to? Someone please? It sounds like it's related to the heart because it has elements associated with the circulatory system but the branchia refers to... it plays a similar role as lung, but in more primitive organisms the gas exchange organs are? (Class murmur) Gills! So branchia means gills. (Class 18)

Professor Brown asks questions to the class or to individual students. The call and response approach to the EALBT gives students the opportunity to practice the instructional approach themselves, by finding the meaning of the root terms introduced. Professor Brown asks questions such as "where have we heard this before?" prompting students to recall previously introduced terms to connect with the novel term.

Visual

In order for a case of the EALBT to fall into the sub-facet of a "visual" case, there needed to be the presence of some form of visual aid, this could come in the form of a drawing, picture,

the writing of a word on a chalkboard, or even the use of a body movement to describe the meaning of a morpheme. In Class 9 we can see a visual case when Professor Brown introduces the term *cephalopods* to his students. During his explanation, Professor Brown writes the morphemes on the board which could aid students to clarify their meaning:

> In cephalopods, they have evolved into a pigment to transfer respiratory gasses, our pigment in our blood cells being hemoglobin is a characteristic of vertebrate respiratory pigment. In the cephalopods it is *hemo* (writing) *cyanin* (writing) so *cyanin* is a molecule that gives blueness to color. *Hemo*, referring to blood (Class 9)

The example given above is a verbal explanation of the term hemocyanin, however there is an added aspect of a visual sub-facet. Professor Brown wrote the term down on the blackboard and gestured to the morphemes when explaining what each meant. Visual indications for instruction have been found to be useful for memory retention, and therefore can be a useful prompt to add to the EALBT (Mathew & Alidmat, 2013). Visual indications could additionally come in the form of pictures on a slide, or body movements from the professor.

Replacement Term

A case was defined as a replacement word form when there was a term introduced to students that could be associated with the alien term to form connections and decipher the meaning of the novel word, the connections were generally formed using shared etymologies and morphemes. I observed an example of the use of a replacement word in class 20. When breaking down the term *gymnophiona*, Professor Brown associates the term with other, more accessible words.

> But getting back to talking about the *gymnophiona*, they are limbless, they are lacking their appendages for the locomotory appendages so they're very snake-like and so, the name *gymnophiona*. *Ophiona* means a snake and *gymno* means naked. Isn't that strange? Because I think you know other words that refer to that same etymological root of *gymno* something like a gymnasium and so did you know that a gymnasium was a place you're supposed to run around naked? (Class 20)

In this case we can see Professor Brown using the term *gymnasium* to indicate to students the meaning of *gymnophiona*. He uses an example (that we used to run around naked in a gymnasium) to generate interest in his students and to hopefully make the term more memorable. Connecting everyday language, is a part of effective instructional strategies (Scott, 2016). If an

instructor uses either previously introduced terms or uses words that they can reasonably assume would be known by the students, it can form connections for the students which can aid with memory and retrieval.

There were also multiple cases of a combination of a call and response and replacement word approach to the EALBT that I found in the dataset. In the cases where we see the combination of these two approaches Professor Brown asks the class about other words that could be used to hint towards the meaning of the alien vocabulary term. Having students search for related terms independently gives students the opportunity to practice replacing terms and could form connections among terms.

Replacement Term and Call and Response Combination

There are three cases found in my dataset that use both the replacement term and the call and response format: *thicate*, *annelid* and *caudata*. They tended to be longer than the explanatory cases (which could last only a line or two) as they incorporate classroom interaction (non-rhetorical questions), as well mentioning/introducing two terms (introduce the novel term, mention the replacement term that would be used to form connections). Therefore, this combination generally needs more than one or two lines of dialogue.

> So, the two units here are *sarco* and *pteron*, now I would like to show you how this etymological approach works, in order to identify those root units, the best way is to use other words that we already know that contain the root unit. So, let's start to think of words that contain *sarco*, anyone? Suggestions! Yes! (Class murmur) Sarcophagus exactly! (Introductory Class)

Once again, to qualify as a case of call and response, Professor Brown needed to ask a non-rhetorical question that was relevant to the term being introduced. For the call and response and replacement term combination, those questions could come in the form of "do we know another term that contains this morpheme?" as we saw in the above example, however Professor Brown could additionally ask questions such as "so we are looking at polychaeta, does anyone know what polynomial means?". Therefore, the combination of these two forms of the EALBT could be beneficial with terms that the instructor perceives to be important.

Analysis of Facets

Professor Brown showed the different ways in which an instructor could use the EALBT and incorporate it into their classroom. To further analyse the forms of the instructional

approach, I counted the number of times each facet was used by Professor Brown in his zoology classroom. The tally for each facet factored into my second analysis, when I observed the metacognitive aspects to this methodology, and whether I determined any differences to the application of metacognitive instruction based on the facets for the EALBT. Table 3 shows the number of instances for each facet and sub facets of the EALBT. Although there were 27 cases of the EALBT in my dataset, there are more than 27 facets that were found, there were a total of 48 facets found due to how these can be stacked upon each other.

Table 4

Facets of the EALBT, and each case that can be attributed to the facet

Case	Form(s)
sarcoplasm	replacement
binomial nomenclature	explanatory visual colloquial
polyphyletic	explanatory
cephalization	call and response
gastrulation	explanatory
diploblastic	explanatory
acoelomate	explanatory
monoecious	visual colloquial replacement
gonozoid	explanatory
thicate	visual call and response replacement
Platyhelminthes	call and response colloquial
lophotrochozoa	visual explanatory
protonephron	call and response
spermatophore	visual explanatory
hemocyanin	visual explanatory
annelids	replacement word call and response

polychaeta	visual explanatory
notapod	visual explanatory
protopodite	explanatory colloquial
lepidoptera	explanatory colloquial
parasitoid	explanatory colloquial
Enteropneusta	colloquial replacement word
pterobranchia	call and response colloquial
urochordata	call and response
amphibian	colloquial explanatory
Gymnophiona	colloquial replacement term
caudata	call and response replacement term

Table 3 reveals that the explanatory facet of the EALBT was used the most often in this dataset. Of the 27 cases found, 16 of them used the explanatory facet. Both the replacement word and call and response facets to the EALBT appeared the fewest amounts of times, only appearing in 7 cases each, visual explanations followed closely behind with 8 cases, and finally colloquial explanations fell in the middle with 10 cases. The explanatory format was used the most often and as I described, is the more straightforward or "basic" approach to the EALBT. Professor Brown needs only one or two lines of dialogue (which only takes around 10 to 15 seconds) to use this form and therefore it could be useful if there are time constraints in a class or for terms that are potentially not as important for the course (which would be left to professorial discretion)

I observed the extent to which there is an overlap for facets of the EALBT. *Binomial nomenclature*, as an example, is seen under the explanatory, colloquial explanation, and visual explanation facets, meaning all these approaches to the EALBT are used to explain the morphemes in one single case. I only found one other case that uses three approaches to the EALBT, *monoecious*, in my dataset, which uses visual, call and response and replacement term

facets. From the remaining 25 cases, 9 have only 1 approach to the EALBT, while the rest use two.

The data presented in Table 3 describes the variety of approaches used by the instructor when conducting a case of the EALBT in his classroom. Additionally, I was able to identify some combinations in the methods that contribute to the diversity. From the examples I provided, the diversity in the cases of the EALBT is discernible. There are shorter and longer cases, as well as ones in which the students were encouraged to actively participate. There could be approaches to the EALBT that are not documented in this analysis, or potential approaches that are not currently used by this instructor.

During my data collection, I searched for classes that contained multiple cases of the EALBT. From the collected data, it can be observed these selected courses contained a larger number of explanatory cases when compared to the other approaches. There additionally seems to be a difference regarding the amount of detail for the in-class analysis of terms. The example I provided for the explanatory approach does not go into as much detail when compared to the example I provided for the call and response format. The instructor repeats himself, reiterating the definitions of the terms. The brief definition could indicate that the instructor does not anticipate that the terms introduced using the explanatory will be of the same importance as the terms introduced using a longer form of the EALBT, it could additionally indicate that the term has some importance, however the instructor does not have the time to be able to introduce and explain the term in depth.

Analysis of Metacognition and the EALBT

This thesis explored one way in which a university professor incorporated metacognitive aspects of instruction into a vocabulary instructional approach. I therefore analysed the metacognitive aspects of instruction and how Professor Brown brought them into his classroom. In order to investigate the EALBT as a metacognitive instructional tool, I needed to first determine whether the EALBT could be defined as metacognitive in nature. A metacognitive intervention would be built with the intention of teaching metacognitive skills for students (Huff & Nietfeld, 2009), and therefore if the EALBT was a metacognitive intervention I would expect to find metacognitive instruction throughout.

The EALBT is meant to change the way the students view their vocabulary. Professor Brown explains in the introductory course: “once you understand how these terms are built you

will be able to acknowledge the meaning and from now on, you'll never have to memorize any of them" (Introductory Class) which is a metacognitive goal. Therefore, it can be reasonably assumed that this instructional approach was meant to be used as a metacognitive intervention in the classroom. The EALBT is constructed to change the way that students think about their vocabulary which is one of the bases of metacognition (Flavell, 1976).

Metacognitive Strategy Instruction

One aspect of metacognitive strategy instruction that is present in the literature, is that an instructor should begin with an explanation of the instructional strategy, explicitly explain the strategy, and give students an introduction of *when*, *how*, and *why* they should use the instructional strategy (de Boer, et al., 2018). Professor Brown fulfills this initial introductory explanation in the first class, when he gives context to how the students were introduced to the EALBT method, and how it was initially explained to them.

> And the list of keywords may be several dozen key words per chapter so do the tally we're talking about, possibly hundreds of new terms that need to be known, understood, explained and defined. Now I'm not saying this to freak you out and to make you all worried about the workload that will be required, in fact I'm saying it for the opposite reason. Because we have a way to deal with this and you will hopefully be able to explain and make that clear. And let me tell you with a number of terms that you are to know memorization and regurgitation just won't cut it. I have a way for us to learn this without having to do that at all. And one of the, well let me just say. For example, if we look along here, we can see that there are a lot of roots to the words that you will recognize right? So, if you were to say archeocyte, right? Archeocyte is made up of *archeo* and *cyte*, so you recognize *archeo* as being referred to like ancient or old right? Like archeology is the study of the old times, right? And *cyto* referred to cells, right? Like cytoplasm being like the liquid inside cells, so the idea here is whereas these terms appear new, they may appear foreign they are entirely recognizable and when you are able to recognize the roots you know the definition of the word. Because that is how science terminology works. It is built of root meanings and when those root units are put together, they give you the definition of the word. (Introductory Class)

Therefore, through these passages here, we can see the *when*, *how*, and *why* for the EALBT. The *when* for this instructional approach is that it can be used when there is a term that is alien, or

unknown to the students. The *how* comes from a demonstration of how to use the instructional approach. Finally, the *why* emerged when Professor Brown explained that students should try to use this approach as there are too many terms for them to memorize outright. Through these passages, Professor Brown gives the initial introduction to the methodology to his students to contextualize every instance that follows.

Examples of Metacognitive Instruction

To demonstrate what I was looking for throughout my dataset I will give an example of each metacognitive aspect of instruction. In this section, I demonstrated how they would appear in the context of the EALBT. Each metacognitive aspect of instruction has been documented as improving students' metacognitive abilities, however, some of the research papers do not include examples of the metacognitive aspect as practiced in class and therefore I relied on the description provided by the authors. For example, in Kistner et al. (2010), explains explicit strategy instruction, "[o]n the other hand, a teacher can *explicitly* tell his students to show a certain activity, for example by explaining that this activity is a learning strategy and can improve their performance", this example does not provide an in-class example of how an instructor could teach a strategy in an explicit manner. Therefore, in this section, I have provided examples of each metacognitive aspect of instruction that I found in the research.

Non-countable aspects

There was one metacognitive aspect of instruction found in the literature that could not be enumerated, which was consistent practice. When using consistent practice, the metacognitive strategy (or metacognitive instruction) is used across multiple classes or is used multiple times in one class to give students the opportunity to practice their skills. Each class chosen for this dataset had no less than three cases of the EALBT, which indicates towards consistent practice throughout a class, these classes ranged from the beginning to the end of the semester, which indicates to consistent practice throughout the semester, and each case of the EALBT had at least one instance of metacognitive instruction for the students, with an average of slightly over 3 instances of metacognitive aspects of instruction per case of the EALBT. Therefore, there is consistent practice of the EALBT itself throughout the classes, the semester, and there is additionally consistent practice for the metacognitive aspects of instruction that can be found in this instructional approach. The difficulty with consistent practice is counting the instances of this metacognitive aspect of instruction. I can determine that this metacognitive instructional

approach was used consistently, however as Scharlach (2008) described consistent practice as "use across multiple lessons" I cannot definitively quantify consistency according to the definition provided.

Countable metacognitive aspects found in the EALBT

Outside of consistent practice, there are countable aspects of metacognitive instruction including explicit strategy instruction, verbalization, and though process aspects.

Explicit strategy instruction

The first countable metacognitive aspect of instruction, and the one that was prevalent in the research on metacognitive strategy instruction is explicit strategy instruction (Dunstone & Caldwell, 2018; Hong et al., 2016). A viable approach for teaching a metacognitive instructional strategy is explicitly explaining what the strategy is, how it is implemented and why students are using it.

In class 18, when breaking down the term *pterobranchia* Professor Brown says "[s]o these sorts of etymological links should be accessible to us and be able to be used as a means to demystify words and not have to memorize them" (Class 18). The example provided is an instance of explicit strategy instruction that explains why the method is effective and why a student should use it. Professor Brown intends for his students to use the EALBT to "demystify" their vocabulary terms to be able to link them easily with other terms to ease access to these terms.

Professor Brown explained to his students in the second class that he uses this instructional approach so that students would "not have to memorize [classroom vocabulary]" (Class 2). Understanding as opposed to memorizing terms would be beneficial for students, because it would ease access to their classroom vocabulary.

There are additional factors to explicit strategy instruction, including modelling a strategy (Kistner et al., 2010). To model the strategy, the instructor demonstrates what they want their students to do, ideally while explaining what they are doing and what they are thinking throughout (Fisher, 2002). From class 6 there was an example of Professor Brown modelling the EALBT while explaining the term *gonozoid* to the class, "*gono* referring to the reproductive units, *zoid* to the little animal and also the synonymous aspect of this is *gonangium*". Professor Brown was modelling the strategy, as he called out the root terms *gono* and *zoid*, and then explained what each meant. The example provided demonstrates a process that students could

follow, even if they are not overly familiar with the term *gonozoid* they may be familiar with this root term, or potentially other words that use this root term *gono* (i.e., gonad). In this case, there was not an explanation of the thought process behind the modelling, however it is still modelling for the EALBT.

A third aspect of explicit strategy instruction that I found throughout my dataset was direct instruction. The previously mentioned approaches of modelling and explaining benefits are parts of direct instruction, however an additional piece would include mentioning when the strategy is being used. An example of this in explicit strategy instruction is when Professor Brown used a "call-out" to the strategy, announcing that he will be entering into a case of the EALBT. From class 2, while explaining a concept having to do with the term *polyphyletic,* there is an example of this direct instruction or "call-out", Professor Brown says, "now let's get back to the etymology of these words" (Class 2). The instructor in this case explicitly made a statement to the students that this will be a case of the EALBT. After a "call-out", Professor Brown could model the strategy or ask for students to identify the terms themselves, however, the inclusion of the "call-out" can still qualify any case as having an instance of explicit strategy instruction. There is a similar case of this kind of "call-out" once again in Class 6 when Professor Brown says, "ok so as usual we like to see that the words in all of these cases means something" (Class 6). This phrase is not modelling or explaining benefits; however, it is still explicit strategy instruction as it is directly mentioning the idea of etymology and its connection with understanding of terms.

Verbalization

Verbalization was another metacognitive aspect of instruction that I found in my dataset. Verbalization is a metacognitive aspect of instruction in which an instructor thinks aloud, explains what they are doing. As we can see from Table 4, this can be considered a part of explicit strategy instruction (showing students what you are doing, and explaining your thoughts), however Scharlach (2008) and Ellis et al., (2014) both gave this metacognitive aspect of instruction its own category and therefore I did as well. When collecting my data, instances of metacognitive instruction that fell under verbalizations were explanations of thought processes, compared to the "whys" behind the method and modelling that we saw with explicit strategy instruction. Verbalization aspects allow students to experience their instructor's thought process

so that they can model it in the future, or so that a student can understand how an instructor comes to the conclusions that they make.

In class 2, when introducing the term *sarcoplasm* to his students, Professor Brown verbalizes his thoughts, "and I just wanted to point out that you were right, and I was confused and so that's why because afterwards I was like 'what's nagging me about this?'" (Class 2). This example demonstrates Professor Brown speaking his thoughts aloud, however we do not see explicit strategy instruction through this sentence. There are two indicators in this sentence that point towards this being an instance of a verbalization. Professor Brown begins this sentence by mentioning that he was confused, which is an example of an explanation of his thoughts, i.e., confusion. Further into this sentence Professor Brown speaks an internal thought aloud by saying "I was like, 'what's nagging me about this?'", in this phrase Professor Brown using the word "like" is an indicator to his internal thought process and allowing students to follow along with him.

To further explain what is meant by verbalization there is another example from class 2. When explaining the term *acoelomate* to his students, Professor Brown says, "if we're to skip the *pseudocoelomate* for now and talk about *eucoelomate* because it makes a little bit more sense if we do it in this order". From this example, we can see Professor Brown explaining his thought process behind explaining one term before another term. The indicator in this sentence of a verbalization of a thought process comes from Professor Brown mentioning that he believes that explaining one word will help students with understanding a second term (*eucoelomate* will feed into understanding of *pseudocoelomate*).

There are additional modes to using verbalization that were not identified in my dataset. Any instance of Professor Brown encouraging students to think aloud or creating a thought guide for his students would have also been included in this section. For instance, if Professor Brown were to say "I want you to break down the term *suprapharyngeal* and then explain what you did and why to the student sitting next to you" that would be counted as a verbalization. In this case, Professor Brown is encouraging verbalizations in his students which would place it that category.

Thought process

Another metacognitive aspect of instruction has to do with managing the thought process of learners. An instructor can work to influence the metacognition of their students if they focus on students' thought process, either by guiding it or identifying it. Managing the thought process

of students has been shown to increase metacognitive controls for students as metacognition has to do with students recognizing and controlling their thought process (Martinez, 2006).

Managing a student's thought process can include focusing the learner's attention on concepts the instructor perceives to be of importance. When identifying the thought process aspects of metacognitive instruction, I worked to identify pieces in my transcripts in which the instructor directed a student's attention on the problem they needed to solve. From Class 9, when introducing the term *annelid* Professor Brown uses a rhetorical question that could work to focus a student's attention, Professor Brown says, "[s]o what is this name, what's an *annelid*?" (Class 9). Rhetorical questions can be used as a prompt for students and can help with message persuasiveness (Blankenship & Craig, 2006). The use of questions and rhetorical questions is one form of attention focusing prompt that is used by Professor Brown. The use specifically of "so what is this name" indicates that this word is about to be broken down, or that this name *annelid* may be important in the future. The rhetorical question, the prompt by Professor Brown works to focus the student's attention on this term, and on the problem, they must solve, in this case, figuring out the name annelid.

Prompts that are used to focus a student's attention could come in different forms outside of a rhetorical question. As an example, from Class 18 when breaking down the term *urochordata*, Professor Brown mentions, "and of course, hopefully this should help us to understand the name of this sub-phylum *urochordata*" (Class 18). Professor Brown mentions that "this should help us to understand", "this", referring to morphological components to this group of animals which indicate towards its name. He additionally uses "us" to indicate that both himself and his students will be working on this problem of deconstructing and working to understand this term. Through this example, we can see how Professor Brown can focus a student's attention on the problem at hand, without using rhetorical questions.

Another means by which an instructor can focus a student's thought process is to activate a student's prior knowledge to help bring new information into their working memory (Quigley et al., 2018). Forming connections to past knowledge is one of the fundamental principles of the EALBT, where Professor Brown encourages connections between terms. Students work to understand novel terminology by breaking it down into its root terms and either match those root terms with words they already know, or by learning those terms through inferences. For instance, in Class 6 when reintroducing the term *thicate*, Professor Brown says, "we had talked about on

the very first day, in particular that there's a couple of French words that employ it, whereas it's not quite as common in English" (Class 6). Professor Brown is activating prior knowledge in his students through this statement, he references a discussion they had previously at the beginning of the class, which should work to activate any knowledge gained from that initial discussion. There is a second prompt in this statement that works to activate prior knowledge, if the reference to the discussion from the first class was insufficient to activate a student's memory, Professor Brown mentions that we should not be looking for a term in English to identify this term, but rather French terms.

To activate prior knowledge, an instructor could additionally reference previously known material that they believe a student in their class "should" know. In my data, any case where the instructor refers to knowledge that he believes a student would most likely be cognisant of was counted as a case of an indication that Professor Brown was activating prior knowledge. For the cases of the EALBT collected for this paper, he did not seem to assume that every student in his course would have a complete understanding of word morphology. In Class 2, when introducing the term *acoelomate*, everything is explained to ensure that his students have essential knowledge they might need for his course "*a* as a prefix meaning absence of, absence of a *coelom*" (Class 2).

Unrepresented Metacognitive Aspects

There are some aspects of metacognitive instruction that do not seem to be measurable within the scope of this study. One of the metacognitive aspects of instruction is assessment integration, in which students learn what instructors expect of them for their assessments, and do those tasks well (Brookhart, 2001). From my dataset, there were no indicators that any cases of the EALTB were connected to a specific assessment (i.e., Professor Brown stating something to the effect of "remember this term, you'll need if for your midterm") and, although students could learn the importance of vocabulary (or the perceived importance the instructor places on their classroom vocabulary) it is not intrinsically linked with a form of assessment. Assessment integration can indicate to students' ways in which their instructor wants them to learn to become successful at tests or assignments and therefore successful in the course.

The second missing metacognitive aspect of instruction is engaging curriculum, which revolves around conceptual instruction and problem-based learning. An example of engaging curriculum would be providing a student with the opportunity to practice their metacognitive

skills (in this case to "think differently about their understanding of their vocabulary") and asking them to solve a problem. If Professor Brown were to, as a part of a practice examination question, use a novel term and ask students to determine the meaning of the term as a part of answering the question. In that case, students would be given an opportunity to practice their metacognition as well as be working with problem-based learning.

There is another situation not seen in my dataset in which students are provided with the opportunity to practice their metacognitive skills. There is an example of this metacognitive aspect of instruction in the introductory class (which was not included in my dataset) when Professor Brown is explaining this methodology, although this class is not a part of my dataset (during this class, the EALBT was not used to teach content, only introduced). During this case of the EALBT, Professor Brown asks his students to think of words that contain the same morphemic roots as the novel term *Sarcopterygii*:

> So, the two units here are *sarco* and *pteron*. Now I would like to show you how this etymological approach works. In order to identify those root units, the best way is to use other words that we already know that contain the root unit. So, let's start to think of words that contain *sarco*, anyone? Suggestions! Yes! (Class murmur) Sarcophagus exactly! Now not to put you too much on the spot but can you tell me very generally what a sarcophagus is? (Introductory Class)

From this example above, we can see the opportunity given by Professor Brown to provide his students with a chance to begin to form connections between terms. This instance occurs in the introductory class, and therefore Professor Brown seems to be setting his students up in a way that they could then use this strategy independently in future courses.

Metacognitive inventory

The metacognitive aspects of instruction used by Professor Brown generally consist of explicit strategy instruction, verbalizations, thought process management and consistent practice. Of those aspects of metacognitive instruction, verbalizations, thought process management and explicit strategy instruction were tabulated for this study. There are two metacognitive aspects of instruction that were not encountered in my dataset: assessment integration and engaging curriculum.

Table 5

Instances of metacognitive aspects of instruction found in the cases of the EALBT collected in the dataset

Case of the EALBT	Metacognitive Aspect(s)	Case of the EALBT	Metacognitive Aspect(s)
sarcoplasm	6	*hemocyanin*	2
binomial nomenclature	5	*annelids*	5
polyphyletic	3	*polychaeta*	2
cephalization	2	*notapod*	1
gastrulation	1	*protopodite*	2
diploblastic	1	*lepidoptera*	3
acoelomate/pseudo coelomate	4	*parasitoid*	4
monoecious	3	*Enteropneusta*	5
gonozoid	1	*pterobranchia*	5
thicate	5	*urochordata*	5
Platyhelminthes	5	*amphibian*	3
lophotrochozoa	2	*Gymnophiona*	4
protonephron	3	*caudata/Anura*	10
Spermatophore	2		

I found a total of 97 countable metacognitive aspects of instruction (outside of consistent practice). The number of metacognitive aspects of instruction found in each case ranged from one instance, to 10. There is a range of the instances of metacognitive aspects of instruction, from the cases found in my dataset.

There are four cases in my dataset that each only had one instance of metacognitive aspects of instruction, explicit strategy instruction (either modelling or direct instruction of the strategy). The term *Caudata*/*Anura* from Class 20 has the highest number of metacognitive aspects of instruction with 10 aspects in one case.

Analysing the Metacognitive Aspects of Full Cases of the EALBT

Through the past analysis section, I have provided examples of each of the metacognitive aspects of instruction that I found in my dataset, however I wanted to additionally demonstrate how these metacognitive aspects of instruction has been woven into instruction by Professor Brown. I have provided two examples, one that has a large number of metacognitive aspects of

instruction, and one that has a low metacognitive aspect of instruction to view the dichotomy between each of these cases.

Higher Metacognitive Case

Below, there is a case of the EALBT from Class 6 in which we can see multiple aspects of metacognitive instruction used by Professor Brown. In this case of the EALBT, we can see how one aspect of metacognitive instruction can lead to another, or both can occur in the same sentence or phrase. In this case of the EALBT, Professor Brown breaks down the term *monoecious* for his class.

> So as a reminder generally speaking these higher classes of *cnidaria* are *dioecious* species, right? Meaning they are not hermaphrodite or *monoecious* they in fact have two different sexes being male and female. I don't remember if I wrote that word for you, so I'll do it again just in case it is something that I haven't explicitly identified yet, but of course if we remember the etymology of *monoecious* that means *mono oikos* meaning one house and *dio-oikos* meaning two houses. So, *di-o-e-ci-ous* (sounding out as writing on blackboard) is how we describe organisms that have one of two sexes, so male or female (Class 6)

Professor Brown begins this interaction with the class with a "as a reminder" which is a prompt used to activate prior knowledge in students. Professor Brown had, in an earlier class, introduced and explained the term *dioecious* (whether through a case of the EALBT, or a simple definition) and therefore reminder the class of this word that was introduced to them before will activate that knowledge and make it more accessible, increasing the student's ability to deduce the meaning of the new term *monoecious*.

Professor Brown uses a similar metacognitive tactic in the next phrase, "I don't remember if I wrote that word for you" however, even though it is a very similar phrase, this metacognitive aspect of instruction is a verbalization of a thought process. The verbalization of a thought process works to indicate to students that there might be a case of the EALBT starting. Professor Brown uses signals like this one mentioned during some of the cases. Some of these indications are explicit strategy instruction, for instance in Class 2 Professor Brown begins a case of the EALBT with "now again, etymology is at the root of our understanding of all of these terms" (Class 2) which is not a prompt for students. However, it is an instance of explicit instruction during an introduction to a case of the EALBT, therefore although these two

introductory sentences appear similar, they contain different strategies for metacognitive aspects of instruction.

The verbalization of thought process continues into the end of the sentence; however, we can see how there is additionally explicit strategy instruction "I'll do it again just in case it is something that I have not identified yet, but of course if we remember the etymology of *monoecious*." Professor Brown is explaining his thought process of what he is doing "I'll do it again just in case," however when he mentions etymology or the identification of terms, that falls into explicit strategy instruction.

As Professor Brown was verbalizing his thought process, the metacognitive aspects of instruction shift into an explicit strategy instruction, with direct instruction of the strategy. Professor Brown mentions etymology, "but of course if we remember the etymology of *monoecious* that means *mono-oikos* meaning one house and *dio-oikos* meaning two houses". This is an example explicit strategy instruction in which he is explaining what he is doing and modelling the strategy of the EALBT to his students. Professor Brown introduces the morphemes *mono* and *oikos* and explains what they mean to his students (*one* and *house*). Professor Brown moves quickly through this explanation; however, it is understandable as he begins this sentence with "but of course if we remember the etymology" which indicates that he might have previously introduced this term, and this case of the EALBT is a reminder for the students rather than a completely new introduction of a term. Therefore, we can assume that Professor Brown could be forming connections to previously known information and reinforcing these connections for his students.

There were no further metacognitive aspects of instruction to be found in this instance of the EALBT, and the final sentence was a wrap up and final explanation of the term. After this sentence, Professor Brown moved on to the next subject, ending this case. This case of the EALBT demonstrated multiple instances of metacognitive instruction, it is additionally exemplary of the ease by which metacognition can be integrated into instruction. Small cues given by instructors could be indicative of metacognitive instruction when used as a means of creating connections between material or to change the way that students think regarding their school material.

Lower metacognitive case

There are cases of the EALBT with few instances of metacognitive instruction, some with only one occurrence. In class 2 when introducing the term gastrulation, Professor Brown uses one metacognitive instructional technique.

> [T]his process of creating this gastric tract is known as gastrulation. *Gastru* as a term refers to sort of stomach or intestines, gastrulation is the process of forming that and it starts with the infolding or invagination of that blastula and once it does invaginate and start to form the digestive tract or this gastric cavity it becomes known as a *gastrula* (Class 2).

In the first sentence, Professor Brown introduces and contextualizes the term *gastrulation*. In the second sentence Professor Brown uses some explicit strategy instruction, by modelling the EALBT "*[g]astru* as a term refers to sort of stomach or intestine, *gastrulation* is the process of forming that". In this case we do not see any additional verbalizations, activation of thought process or explicit strategy instruction. We can count this as an instance of consistent practice, as any opportunity to see the EALBT being used by Professor Brown will be beneficial for students to learn how to use it, and under what circumstances to use it.

There could be a few reasons as to why Professor Brown only uses one metacognitive aspect of instruction in this case. There is also only one morpheme introduced in this case *gastru* as the suffix *ation* is not specifically explained to the students which could make this case shorter. This case of the EALBT would aid students with practicing the EALBT as a model of how they could use the strategy, however it does not contain many of the aspects of instruction that have been shown to increase metacognition in students.

Statistical Analysis of Forms of the EALBT and Metacognition

In my first two analysis sections, I explored the forms Professor Brown used for the EALBT in his classroom and the metacognitive aspects of instruction attributable to the instructional approach. In this statistical analysis, I explored whether there was a statistical significance in the use of metacognitive aspects of instruction found in the 5 forms of the EALBT. The statistical analysis demonstrates the most fruitful way of increasing metacognitive instruction in the classroom using the EALBT and therefore how metacognitive instruction can be incorporated into a course.

Before beginning my analysis on the forms of the EALBT, I had made assumptions that there would be strict delineations between the forms used for the instructional approach. Verbal

data in a classroom environment, however, does not generally have the same level of formality as written data (Lemke, 2012) and therefore, a verbal dataset may not always have a strict delineation in categories. After watching through the full classes, it emerged that the forms can at times layer, and they do not always appear independently (i.e., I have sub-facets that do not appear independently). As I was collecting the verbal data to be used for my analysis, the blending and combination of the categories that were developing became clear. As an example of this blending, there were cases where Brown would ask a question while using a visual aid such as drawing on the whiteboard or pulling up a picture. As we can see in Table 6 below, there are multiple forms of the EALBT, which can occur together and be layered on top of each other. The combinations seemed to be centered around the visual and colloquial forms of the EALBT, however there were additional combinations of the call and response, and the replacement term forms (3 cases in which these two forms were combined).

Table 6

Cases of the EALBT found in my data with the number of metacognitive aspects of instruction and their attributable forms

Case	Form(s)	Metacognitive Aspects
sarcoplasm	replacement	6
binomial nomenclature	explanatory visual colloquial	5
polyphyletic	explanatory	3
cephalization	call and response	2
gastrulation	explanatory	1
diploblastic	explanatory	1
acoelomate	explanatory	4
monoecious	visual colloquial replacement	3
gonozoid	explanatory	1
thicate	visual call and response replacement	5
Platyhelminthes	call and response colloquial	5
lophotrochozoa	visual explanatory	2

protonephron	call and response	3
spermatophore	visual explanatory	2
hemocyanin	visual explanatory	2
annelids	replacement word call and response	5
polychaeta	visual explanatory	2
notapod	visual explanatory	1
protopodite	explanatory colloquial	2
lepidoptera	explanatory colloquial	3
parasitoid	explanatory colloquial	4
Enteropneusta	colloquial replacement word	5
pterobranchia	call and response colloquial	5
urochordata	call and response	5
amphibian	colloquial explanatory	3
Gymnophiona	colloquial replacement term	4
caudata	call and response replacement term	10

In Table 6 we can see that the visual and colloquial forms of the EALBT are sub-facets as I described in my initial analysis of the EALBT. These are forms that were not found to exist on their own, but rather, they are supplementary to other forms. In addition to these forms not existing on their own in my dataset, the visual and colloquial forms do not have attributable aspects of metacognitive instruction found in the literature. There is no metacognitive aspect of instruction found in the literature that is linked to visual or colloquial instructional styles (which is not the case for the other forms of the EALBT found in my dataset). In the literature, there is no mention of visual instruction leading to an increase in metacognition for students. Similarly, easy to understand language was not found to be indicative in the literature of an increase in metacognition for students.

Therefore, considering the lack of metacognitive aspects of instruction attributable to these sub-facets and to have a clearer dataset, I continued with a dataset that did not contain the visual or colloquial forms of the EALBT. There is no metacognitive aspect of instruction that was found in the literature to be linked to either of these sub-facets therefore they did not influence the number of metacognitive aspects of instruction for each case and so eliminating them only made my dataset more accessible for analysis. I additionally set up the analysis to be inclusive of the combination of the call and response and replacement term form, as this combination appeared three times in the dataset. Therefore, my categories for my analysis were: 1. explanatory [E], 2. replacement [R], 3. call and response [C] 4. combination of call and response and replacement [A]. These four categories are what I will use to conduct my statistical analysis.

To begin my statistical analysis, I used a comparison of means with an ANOVA analysis to determine if there was a significant difference between the means of any of the forms found. The average number of metacognitive aspects of instruction for each form was found by a statistical program SPSS, the program then compiled an ANOVA table determining whether there is a significant difference in the means. The means and the attributing number of cases can be found in Table 7 below.

Table 7

Forms of the EALBT with their average number of metacognitive aspects of instruction

Form	Number of cases (*n*)	Mean of metacognitive aspects ($\overline{x}$)
Explanatory [E]	15	2.53
Call and response [C]	5	4
Replacement [R]	4	5
Call and response and replacement [A]	3	6.67

The explanatory form [E] had the highest number of cases with the lowest average number of metacognitive aspects of instruction ($\overline{x}$=2.53), this form of the EALBT was used during some classes as a quick aside, a quick one-line addition to further explain the meaning of a term that does not go into much detail or take much time away from the course. As a result of some of these quick cases of the EALBT, there tends to be fewer instances of metacognitive aspects of instruction. Although these cases are not as metacognitive, I will discuss in my discussion section the benefits of these shorter cases.

The call and response and replacement combination [A] had the highest average metacognitive aspects of instruction. The combination is technically two forms being used during one case; therefore, this increase would make sense. The ANOVA was used to determine if there is a significant difference somewhere between the means, however, to find where the differences lie, I conducted pairwise comparisons. These pairwise comparisons were important to conduct, to determine if there was any form that had significantly more metacognitive aspects of instruction compared to another.

For the ANOVA table, Table 8, the mean of the number of metacognitive aspects of instruction for each form of the EALBT were compared against each other to determine if there is a significant difference in the means ($\alpha<0.05$). The initial ANOVA analysis indicates whether there are any significant differences among the means of the metacognitive aspects of instruction for the different forms of the EALBT. Once a significant difference was determined, a more in depth pairwise analysis was conducted to find where the significant differences lie. If no significant difference was found in the ANOVA table, no pairwise comparisons would have been conducted. From the ANOVA table below, I determined that there is a significant difference in the means.

Table 8

AVOVA comparisons of means for the 4 categories of the EALBT

		Df	Mean square	f	Sig. (α)
metacog*form	Between groups (combined)	3	17.965	7.075	0.002
	Within groups	23	2.539		
	Total	26			

The significance value found from the initial ANOVA is $\alpha=0.002$ which is smaller than $\alpha=0.05$ and therefore there is a significant difference in the means for my metacognitive aspects of instruction. As I mentioned, once this ANOVA came back with a significant difference, I then had to explore where these differences lie. I conducted pairwise comparisons between the means of all my forms of the EALBT. Six pairwise comparisons were conducted as can be seen in table 12 below. Once again, I was looking for a significance level under $\alpha=0.05$ to see where the differences lie.

Table 9

Pairwise comparisons between the means found between each of the forms of the EALBT found in the dataset.

					95% Confidence Interval for Difference	
(I) form	(J) form	Mean Difference (I-J)	Std. Error	Sig[b] (α)	Lower Bound	Upper Bound
E	C	-1.467	0.823	0.088	-3.169	0.236
	R	-2.467	0.897	0.011	-4.322	-0.612
	A	-4.133	1.008	<0.001	-6.218	-2.049
C	E	1.467	0.823	0.088	-0.236	3.169
	R	-1.00	1.069	0.359	-3.211	1.211
	A	-2.667	1.164	0.031	-5.075	-0.259
R	E	2.467	0.897	0.011	0.612	4.322
	C	1.000	1.069	0.359	-1.211	3.211
	A	-1.667	1.217	0.184	-4.184	0.851
A	E	4.133	1.008	<0.001	2.049	6.218
	C	2.667	1.164	0.031	0.259	5.74
	R	1.667	1.217	0.184	-0.851	4.184

This table shows the paired comparisons of means, not every pairwise comparison ends up with a significant difference of means. Three of the six comparisons did not end up with a significant difference, these comparisons are: E compared with C (α=0.823), C versus R (α=0.359), and R vs. A (α=0.184). There were no statistical differences found in any of these as indicated by a significance of α>0.05. Therefore, when comparing these sets of forms of the EALBT, there was no significant difference in the metacognitive aspects of instruction as used by Professor Brown.

There is a significant difference between E and R (α=0.011), and E and A (α=<0.001), and between C and A (α=0.031). Therefore, we see a significant difference in the means when comparing metacognitive aspects of instruction between the combination of call and response and the replacement term [A], when it is crossed with either explanatory [E] or call and response [C]. It is important to note that there is not a significant difference when we look at the combination of call and response and replacement terms [A] with replacement terms [R]. The lack of a statistically significant different is important as the combination does have a significant difference with the other two forms of the EALBT (additionally call and response [C] has a significant difference when compared with the combination [A]), which could potentially

suggest that there is something about the replacement term that indicates higher levels of metacognitive aspects of instruction. The potential metacognitive implication of the replacement term approach (as indicated by my statistical analysis) is further supported by the fact that the replacement term form [R] has a significant difference with explanatory form [E], however call and response [C] does not have a significant difference with the explanatory form [E]. Therefore, the use of the replacement term form could indicate higher levels of metacognitive instruction. I will elaborate on these significant differences in my discussion section.

Word List Analysis

As a secondary purpose for this study, I compiled a list made from the important zoological terms as provided by Professor Brown. This analysis aids with understanding the use of the EALBT as it will help describe the process an instructor would need to follow in order to use the instructional method in their classroom. For the terms in this list, I found the etymological morphemes (or the root terms) that showed the history of the terms. This word list should be usable for instructors to find terms with shared morphemes that they could teach to their students.

Trends Found in the Master List

There were some trends found in the master list, some root terms emerged at a higher rate when compared to others, and some root terms were only present once or twice. There are benefits to providing a list of the most frequent morphemes (therefore the morphemes students may encounter most often in their class). In Table 6 there is a list of any etymological root that occurs 10 times or more in my master list. Therefore, introducing these roots to the students would increase their access to at least 9 more terms (and possibly more as my master list is a condensed version of the 2027 terms provided by Professor Brown).

Table 10

Most frequent morphemes in the condensed master list (10+ instances)

Morpheme	Count in Master List	Morpheme	Count in Master List
Classis	75	*Culum*	13
Phylon	37	*Order*	12
Pod	29	*Cilia*	12
Zoion	26	*Di*	12

Pro	22	*Morphe*	12
Cell	21	*Pedicellus*	11
Glandulae	21	*Gaster*	11
Cyto	18	*Re*	11
Musculus	18	*Phora*	11
Meta	17	*Systema*	10
Para	16	*Larva*	10
Coel	14	*Endo*	10
Gene	13	*Phagos*	10
Pharynx	13	*Epi*	10
Stoma	13	*Bi*	10
Porus	13	*Gerere*	10
Derma	13	*Oid*	10
Sub	13	*Ganglion*	10

There are a total of 36 morphemes that were counted to have 10+ instances in my master list. From these morphemes, there were a few patterns found regarding prefixes and suffixes, taxonomic ranking morphemes and animal specific morphemes.

Prefix and Suffix

From this list of the most frequent morphemes, we can find in the master list, we can see a few suffixes and prefixes. For instance, *sub, pro, di,* and *bi* all are prefixes and suffixes. The presence of these suffixes and prefixes in my most frequent morpheme list make sense as they are generally used as qualifiers for terms. For instance, *monoecious* and *dioecious* both have similar root morphemes however they differ by their prefixes. Therefore, these modifiers could work to increase the number of a morpheme such as *di* (meaning two) or *pro* (meaning first).

Taxonomic Ranking

The most frequent morpheme is *classis* derived from *class*. When compiling the master list, any entirely replicated words were deleted, however there were 75 individual terms that had the word *class* due to its use as a taxonomic classification category in zoology. A class of animal is a part of the taxonomic rank for organisms in biology. There were a few classes of animals introduced to the class (from what we can tell from the master list) however, there were

additional instances of terms that contained *infra-class* or *super-class* as a part of the term. These are taxonomic rankings that fall either just above or just below the ranking of *class.* As I have mentioned in the EALBT analysis section, there are some terms that are unbounded (also known as free) morphemes, where on its own, it is a morpheme as well as a term.

The second most frequent morpheme was *phylon* (the etymological root for the term Phylum), which is another taxonomic ranking for animals. This ranking falls above the "class" ranking, and therefore there seem to be fewer of this taxonomic ranking of animals that are introduced to the class. This term is additionally used in terms such as *phylogenetic tree* and *phylogeny*, which increases its instances in the master list. Further down the list we see the term/morpheme *order* which is another taxonomic classification

Animal Terms

Throughout this morpheme list, we see the presence of morphemes that are linked to the form or function of animals, for instance, *pod*, which is Greek for "feet", and *zoion*, which is Greek for "animals and organisms". The presence of these terms in Table 6 (the most frequent morphemes) is reasonable as this is a zoology course which focuses on the form and function of animals, and therefore these morphemes would be expected. If this were a botany class or a chemistry class, these morphemes would no longer be expected to be prolific in the dataset as they would not place the same importance on animal phylogeny form and function as a zoology class would have.

Rare Morphemes

In addition to the most frequent morphemes, there are a large number of morphemes that appear only once or twice in the master list. There are 556 morphemes that appear once in the master list, which works out to be around a quarter of the morphemes present. These rare morphemes may be important for students to know and understand due to their potential alien-ness, they may be unrecognizable to students in a second-year zoology course, one example of a potentially alien morpheme would be *rhizoid.* Not every morpheme that appears only once in the master list is potentially alien, for instance *amoeba* which is a morpheme that appears only once, however would most likely be recognized by students in a zoology course. Whether these morphemes are presented to students would need to be up to professor discretion (as with the more frequent morphemes). As content experts, a professor teaching a zoology course would have a good idea of the morphemes that would have relevance to the students in the course.

There are some rare morphemes that are introduced by Professor Brown during the cases of the EALBT that are in my dataset, for instance *helminthe* only appears once, however the term *platyhelminthe* is introduced to the students in Class 6. Introducing this term is up to the discretion of Professor Brown as he knows what he will test his students on, and he would have a good idea as to what may appear in future zoology courses his students take as a professor of zoology.

There are 412 morphemes that appear only twice and some of these morphemes could qualify as potentially alien (likely to be unknown by students in an undergraduate degree). Once again, professor discretion would dictate which morphemes have enough importance to be introduced to the class. Therefore, there are 968 morphemes that either appear once or twice in the master list. Out of these 968 morphemes a professor could choose one over another to introduce to his students. As I mentioned this would be up to professor discretion, however the reason behind could be due to personal interest by a professor (they introduce a term to their students because they find the etymology interesting). A second reason could be due to

Morpheme Count

In addition to compiling a complete list of the etymological breakdown for the terms, I counted the number of morphemes in each word. There are 281 terms that have one morpheme, 566 terms with two morphemes, 234 with three morphemes, 55 with four morphemes and 4 terms with 5 morphemes. These numbers are represented in Figure 1 below.

It is important to note that terms with more morphemes does not necessarily indicate to a lexically complex term, for instance, one of the 4 morpheme terms is *binomial nomenclature*, which when broken down is *bi* (two), *nomial* (name), *nom* (name), *clature* (to call). *Binomial nomenclature* could be a more recognizable term when compared to one of our dual morpheme terms such as *apophyse* for students in a second-year zoology course. Therefore, the number of morphemes present in the terms in the class does not speak directly to the complexity of the term, however the longer terms may be more beneficial to break down if a professor finds the terms to have value for their students. The value of a term could derive from factors such as its usefulness in a future course or from interest as perceived by the professor.

Figure 1

Distribution of morphemes for the master word list, as found in a second-year zoology course

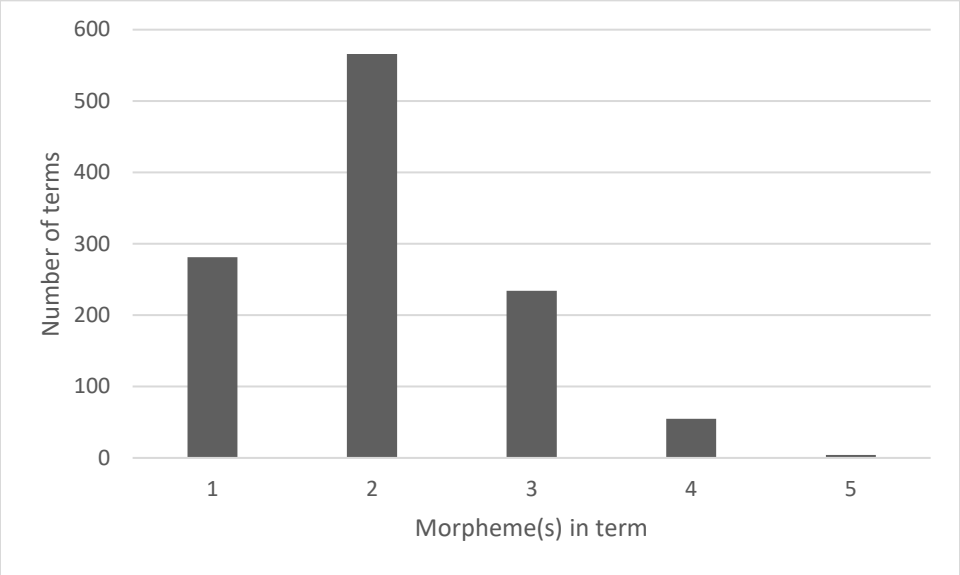

Figure 1 demonstrates that there are many terms that have two morphemes in the master word list, however the entire list ranged from 1 morpheme terms to 5 morpheme terms, for instance *Sub-Phylum Trilobitomorph* (*sub, phylon, tri, lobe, morphe*) which was found in topic 11. Most of the terms that were a part of the master list had 1-3 morphemes, with a smaller number having four or five morphemes.

From the master list that can be found in Appendix A, we can explore the breakdowns for a single morphemic term such as *cuticle* which has the morpheme *cutis*. The introduction may not provide students with as much zoological information when compared to terms with 2 or 3 morphemes. There could be more information given to a student when we consider breaking down a term like *rhabditiform* due to the foreign nature of the term when compared to a term like *cuticle*, which is readily available and used in the English colloquial language. It could additionally be a better use of a professor's time to break down a term that has multiple morphemes. One case of the EALBT could potentially allow a student to understand four or five morphemes which could ease their access to a multitude of other terms that share common morphemes.

Using the Master List

The word list that I have compiled indicates terms that contain high frequency morphemes and low frequency morphemes. The list additionally provides the etymological morphemes of the terms; however, it does not indicate the meaning of the morphemes. Instructors who endeavor to use the EALBT in their classrooms should know the meanings of

each etymological root in order to teach it to their students and may need to find terms with which they could form connections with the novel word.

As an example, from the master list, we know that *zooecium* can be split into two etymological morphemes: zoion and *oikos. Zoion* as a morpheme means "animal", an instructor could potentially guide students to derive this meaning by mentioning terms such as "zoo" (a place where you go to see animals) or "zoology" (a class where you study animals). Therefore, student would understand that nearly any term with a *zo-* morpheme most likely has some connection to "animal". The second morpheme may not be as familiar to students, however *oikos* as a term refers to the concept of the home, family, or unit. English terms such as "economy" and "ecology" derive from *oikos* as well. Economy as a term in this case means the financial situation of a family or another unit (i.e., a country) therefore both *eci-* terms, and *eco-* terms can derive from *oikos*. If this information is introduced to students, they could, without any additional background knowledge, derive that the term *zooecium* refers to some sort of house for an animal, or a grouping of animals. *Oikos* appears four times in my master list and *zoion* appears over 20 times, therefore the instruction of the term *zooecium* could help students understand nearly 30 other terms.

Discussion

Through my analysis, I investigated the forms of the EALBT and whether there were cases that had higher or lower instances of metacognitive aspects of instruction, which was found to be the case in Table 2. As metacognitive instruction has been linked with increases in student understanding and retention of information (Hartman, 2001) the forms with higher instances of metacognitive aspects of instruction should therefore have a greater benefit to students.

Forms of the EALBT and Metacognition

The form of the EALBT with the highest average number of metacognitive aspects of instruction in my dataset was the replacement term and call and response combination. There are a few reasons as to why there could be a higher presence of metacognitive instruction in the replacement term and call and response combination. Part of the reason for a higher presence in metacognitive instruction is that the replacement term and call and response combination form of the EALBT generally incorporated some form of prompt for students from Professor Brown. In class 6 when re-introducing the term *thicate,* Professor Brown used this combination:

> And you'll remember this root, *thica* that we had talked about on the very first day, in particular that there's a couple of French words that employ it, whereas it's not quite as common in English. *Thica* meaning what again please? (Class murmur). A housing, right? Because of say 'le mot pour ou on met les livres le biblioteche' right so biblioteche or discoteche meaning a housing or a case that surrounds something, in that case books or dancers if you will at the discotheque. So, a *thicate* means that there is an envelope some sort of case around them, and this is important to note, well it's important to note that not all colonial polyps of the class *hydrozoa* are *thicate*, in some instances they don't secrete this perisarc and live within a case. (Class 6)

Here, Professor Brown asked one question and made one statement that encouraged his students to recall previously broken-down terms, as a means of guiding their thought process to form connections between the vocabulary terms in the course. Professor Brown made a statement "[a]nd you'll remember this root *thica"* followed by the question "[*t*]*hica* meaning what again please?" These prompts were both use to guide students towards the meaning of *thica*. Professor Brown additionally used prompts in the replacement term format (without the combination of call and response). In class 20, he introduced the term *Gymnophiona* and said, "because I think you know other words that refer to that same etymological root of *gymno* something, like a gymnasium" (Class 20). There was a prompt in this statement when Professor Brown linked past knowledge (the meaning of gymnasium) with novel knowledge (the meaning of *gymno* for *Gymnophiona*). Therefore, we see how Professor Brown used prompts in the call and response format (using questions, "*thica* meaning what again please?") and in the replacement terms format through statements, these prompts were present in most of the cases that use these forms, however they were not seen in the explanatory, visual or colloquial forms. The presence of these prompts could be one of the reasons as to why the replacement term and the call and response terms generally had higher numbers of metacognitive aspects of instruction when compared to the other forms.

The replacement term format was additionally found to have high instances of the countable metacognitive aspects of instruction. The replacement term facet of the EALBT generally provides the students with the opportunity to form connections between previously known or introduced terms (whether from in the course or outside the course) and novel terminology. When Professor Brown introduces a "replacement term" he is aiding the students in

forming connections between two terms that share common morphemes with the objective of students inferring the meaning of the novel term from what they know of the replacement term. Encouraging connections is a part of metacognitive instruction, where previously known material can be incorporated to activate prior knowledge and stimulate metacognitive development (Quigley et al., 2018).

The visual and explanatory forms of the EALBT that were found in the dataset had fewer instances of metacognition, however, they can still be useful for instructors. These forms seemed to be shorter classroom interactions, which is a smaller time commitment for instructors, and reduces the time spent away from other course content (other than vocabulary instruction). Some of the explanatory or visual cases of the EALBT only had one of two lines of dialogue, the term is introduced, followed by the morphemes and their meaning and then Professor Brown moves on. These cases, although they do not generally have high instances of metacognitive aspects of instruction, expand upon their morphology knowledge so that students could deconstruct future novel terms more independently.

Although there I did not find the same amount of metacognitive instruction in the explanatory/visual forms, Professor Brown often still uses explicit strategy instruction during these cases. In some of the explanatory cases, Professor Brown explicitly calls attention to the EALBT and its use in class (a form of explicit instruction). Professor Brown will call to the instructional approach by saying phrases such as “now if we were to think of the etymology of these words”. Explicit instruction is in part meant to refer students back to their *when, why* and *how’s* for a metacognitive instructional approach (if the metacognitive instructional approach has been explicitly explained during an initial lesson). When Professor Brown explicitly mentions etymology, or the etymological approach or “if we remember the etymology” (Class 6) he is creating connections between all of the cases of the EALBT (Scharlach, 2008).

The integration of explicit instruction spanning from the introduction of the etymological approach allows Professor Brown to call back to remarks he had previously made and therefore providing himself with easily accessible references for explicit strategy instruction. For instance, as Professor Brown explained initially how nearly all the terms in zoology are constructed in such a way as to have meaning for those who read them, he can simply say “these words should not be so mysterious after all” (Class 15) regarding a term he had just explained, and students could recall the conversation that occurred regarding the importance of etymology. Instances of

explicit strategy instruction can be as short as one line of dialogue as provided by Professor Brown and therefore would not likely add much instructional burden to new teachers that wish to integrate metacognition into their instruction.

Therefore, whether using a form of the EALBT that has a higher average number of metacognitive aspects of instruction, or lower average number, there could be benefits for students. Factors having to do with the EALBT (which words to choose, or when to implement this instructional methodology) have professorial discretion and therefore, which form of the EALBT to use and when would also be up to their professional opinion. However, there is no evidence that metacognitive aspects of instruction will have a greater impact on students when compared to engaging curriculum.

Knowledge for the EALBT

The different forms of the EALBT found in this study could have different levels of etymological knowledge needed to be used by an instructor. Regardless of instructional level, teachers can have difficulties identifying morphemes in complex terms as they are not trained in etymological knowledge (Washburn & Mulcahy, 2018), and therefore finding this information could require more work on the part of the instructor. In order to use the EALBT, an instructor would need to have etymological knowledge (that they might not otherwise need to know to teach the course). For instance, to use the replacement form a professor would need to know a second term that shares the same etymological roots as the term they are introducing to their students. They would need even further etymological knowledge if they were asking students to find replacement terms (as they would need to be able to identify whether a replacement term put forward by a student shares an etymological link with the presented term). Therefore, although the replacement form generally had many metacognitive aspects of instruction in my dataset, it requires etymological knowledge to use.

The explanatory form and visual sub-facets of the EALBT had the fewest average instances of metacognitive aspects of instruction in my dataset however, they are straightforward for an instructor to implement in the classroom and generally do not require much etymological or morphological knowledge. To use the explanatory form and the visual sub-facet of the EALBT a professor would need to know the meaning of the morphemes to explain them to the class. Therefore, reducing preparation time needed to use this form, and potentially making the EALBT more accessible to instructors.

The call and response format seems to share the properties of the replacement term format that would require the same workload for the instructor, however its preparation could be similar to the explanatory form and visual sub-facet. As we see from Professor Brown, in the call and response format, you can ask students for the meaning of the morphemes in order to engage them in the classroom. For example, from class 6, Professor Brown says "proto and nephron, nephron referring to? (Class murmurs) the kidneys, right! And proto?" (Class 6). In this case, Professor Brown is asking questions for which he already knows the answer and direct the classroom discussion to generate the intended meanings.

Instructor Style

Through watching the entirety of the semester, I developed a sense for the instructional style of Professor Brown. He tends to use colloquialisms and questions during instructional sessions. We see this through cases of the EALBT, where Professor Brown uses layman's terms in order to explain concepts, or as we have seen in my analysis, during the EALBT. Through my analysis of the forms of the EALBT, we can see how these stylistic choices by Professor Brown can be found in the instructional approach of the EALBT. There is a form of the EALBT, in which colloquialisms are used to explain a term, which is most likely attributable to Professor Brown's instructional style as much as the flexibility of the EALBT.

Professor Brown used questions while teaching, some rhetorical and some non-rhetorical. Therefore, these stylistic choices by Professor Brown could additionally be found in the EALBT and its forms. These stylistic choices led me to believe that there are potentially more forms of the EALBT that could exist, however that were not implemented by Professor Brown. I suggested a few in my analysis, for instance, asking students to come up with replacement terms and then discussing them in small groups, or putting the morphemes on a slide with the definition underneath. I do not have counts for the potential metacognitive aspects of instruction available as these forms are not a part of this study. Future professors who chose to use this instructional approach should therefore not be limited to the forms found and studied in this paper.

Word List

As a means of further understanding how an instructor would use the EALBT in their classroom, I compiled the terms provided by Professor Brown for his course into a master list of zoological vocabulary. These terms had been indicated by Professor Brown as having some

importance for the course. Once this master list was compiled, I researched and added the etymological morphemes to the terms. Through the identification of the etymological morphemes, I was able to find connections between terms that could be of use for instructors. Through using this list, instructors would be able to mention any terms that would have connections to the term they are introducing to their student. For instance, I mentioned the term zooecium as having a root *oikos,* as does the term monoecious and dioecy. These connections would not have to be sought out by the instructors.

I additionally identified a few categories of often seen including taxonomic rankings and prefixes/suffixes. I additionally identified the number of rare morphemes present in this master list. There were 500+ morphemes that appeared only once or twice in my master list and therefore, although teaching rare morphemes could be beneficial for students, the instructor would need to identify the important morphemes themselves. University instructors are experts in their field and therefore it is reasonable to assume they would be able to identify important terms or morphemes for the course they are teaching.

Importance of a term for a course could be one route an instructor follows when choosing terms to break down using the EALBT. The abundance of a morpheme in the course could be another reason for an EALBT explanation, however instructor interest could be a reason for choosing a morpheme to break down. Research has shown instructor enthusiasm as an indicator for classroom engagement, which could increase students' achievements (Zhang, 2014). Therefore, if an instructor finds a term interesting, or likes the story of its etymology, that could be a valid reason to introduce that term to students to increase engagement and generate interest in students.

Conclusions

In this thesis I used a case study approach to explore the different forms of the EALBT as used by Professor Brown in his second-year zoology course as a means of investigating one way in which instructors can ease access to science vocabulary. I analysed the forms of the EALBT and investigated the presence of metacognitive aspects of instruction in the instructional approach, and whether some forms had higher instances of metacognitive instruction. As I collected my data and conducted my analysis 3 facets and 2 sub-facets of this instructional approach emerged. The 3 facets were the explanatory form, in which Professor Brown explains verbally the morphology (and at times etymology) of a term, the call and response form, in

which Professor Brown uses a questioning approach (non-rhetorical questions) to explain the morphology of a term, and the replacement term form in which Professor Brown guides students to the meaning of a novel term using terms they might already be familiar with. The 2 sub-facets are a visual form, in which some form of visual instruction is used to supplement instruction (using either pictures or body language), and a colloquial approach in which lay terms are used to explain the novel term. Therefore, through my analysis I was able to discern different facets and sub-facets to the EALBT, each of which could be implemented by future instructors that are interested in using a new terminology instructional approach. Instructors could implement the varying forms according to their instructional style or the needs of their classroom.

Through my case study analysis, I wanted to understand the ways in which metacognitive instruction could be incorporated into a vocabulary instructional approach. Metacognitive instruction was incorporated through prompts to students, prompts in the form of questions to the students, and the encouragement of links between material (from material within the course as well as connections to outside material). Professor Brown also used explicit instruction, and used it consistently across the course, and within classes. Professor Brown consistently mentioned etymology and its importance while using the EALBT, these examples provided are some ways in which the instructor in this case study incorporated metacognitive instruction into their classroom. Therefore, for future instructors to incorporate metacognition into their instruction, they can use similar pathways to Professor Brown.

I additionally identified other means of incorporating metacognitive instruction into instructional methods such as a vocabulary instructional approach and have left it open to future strategies. One purpose of this thesis was to find one means of increasing metacognition in a university science classroom with the purpose of easing students' access to classroom terminology.

As another means of potentially influencing the metacognitive instruction in a university science classroom, I wanted to explore whether any of the facets of the EALBT were accompanied by higher instances of the countable metacognitive aspects of instruction. Based on the data collected from this semester of classes, and the statistical tests conducted, I determined there was a statistically significant difference in the amounts of metacognitive aspects of instruction amongst the forms of the EALBT. The explanatory form of the EALBT had the lowest amount of countable metacognitive aspects of instruction with an average of 2.53

instances per case. Some cases of the explanatory form had only one countable instance of metacognitive aspects of instruction. These cases were short interventions in the classroom, only lasting a line or two of dialogue before moving on to other class content. There would still be use for these cases of the EALBT, short instances in which students can gain vocabulary knowledge, that do not take too much time away from other necessary course content. My data additionally indicated that there were forms of the EALBT that generally came with higher instances of countable aspects of metacognitive instruction.

There could be benefits to using a variety of methods of this instructional approach, which were address in my discussion section, however, I wanted to explore whether any of the approaches documented in this thesis could potentially be accompanied by higher instances of metacognitive aspects of instruction if used in the manner found in this case study. In the case of the EALBT, if an instructor is to use the call and response and replacement term combination, there could be higher instances of metacognitive aspects of instruction when compared to some of the other facets. If an instructor were to use the replacement term facet, there could be higher instances of metacognitive aspects of instruction when compared to the other facets if used in a similar way to the instructor in this case study, however this could still be influenced by instructor style. The replacement term and the call and response combination form had the highest average instances of metacognitive aspects of instruction with an average of 6.67 instances per case. Every case in this category included at least one student-teacher interaction and created one link between previously known information and novel information. With a higher average of metacognitive aspects of instruction there could be a higher likelihood of influencing the metacognitive skills of students if the facet is used in the same way as the instructor in this case study.

Word list

I additionally explored the word list as provided by Professor Brown that consisted of a list of 2470 terms that were reduced to 1625 by eliminating duplicate terms and eliminating phrases from the word list. These terms were broken down into their etymological roots to investigate any potential connections among the zoological terms.

From this analysis I found some repeated etymological morphemes (such as *pro* or *zoion*) that could have benefits if introduced to students. I categorized these repeated etymological morphemes into sections including animal terms, suffixes, or prefixes etc. These categories could

aid instructors in classifying which etymological morphemes they would want to introduce to their students, and which ones could be of use. I additionally pointed out some rare morphemes that could be introduced to students at professorial discretion to increase students' terminology knowledge. I identified 533 rare morphemes (only appeared once in my master list) all of which could be beneficial if introduced to students, however that would need to be left to instructor discretion.

The master list that was compiled in this paper has the benefit of pointing out some of the more commonly used morphemes, however it additionally will provide instructors with a breakdown of some of the terms they might want to explain to their course. Instructors could reference the list provided and it would ideally cut down on some of the excess work that would need to be done by instructors to incorporate the EALBT into their course. The footwork of finding the etymology of some terms that might appear in their course would be completed, and instructors would need to compile the etymologies (and potentially decipher their meanings if not already known).

Contributions, Limitations, and Future Directions

In my thesis, I explored an instructional approach using a case study methodology. The purpose of the case study included investigating the EALBT and how it is used in a university science classroom. Through the analysis of the instructional approach, this thesis explored one way by which an instructor could begin to break down some of the barriers faced by students in their courses. Students have reported facing challenges in learning their course content due to the terminology present in science classes (Krajick & Sutherland, 2010; Zukswert 2019). My case study thoroughly documented the EALBT, and how Professor Brown uses his instructional method in his course. I provided in-class examples of how the EALBT was used, and how it could potentially be used in the future to help students understand their scientific terminology. Therefore, this thesis contributes to the body of literature working toward students' access to the course content and the ways in which instructors could aid students in understanding science class information.

There are some pedagogical implications to this thesis, as it additionally contributes to the body of literature regarding instructional practices. As has been previously mentioned in my literature review, one barrier for instructors adopting new teaching methods stems from a lack of information or resources to teaching methods (Brownell & Tanner, 2012). This case study has

presented the EALBT and provided a potential resource that could be used by instructors through the explanation of the instructional approach as well as providing the word list that supplies the etymology of zoology terms. There are finally some pedagogical implications regarding the use of metacognitive aspects of instruction in the EALBT as influencing the metacognitive skills of university students is important due to the more self-centered learning focus in some university courses (Colthorpe et al., 2018). I demonstrated one way in which metacognitive aspects of instruction could be integrated into course content instruction through the teaching of course vocabulary.

There were limitations that I encountered while gathering my data. I conducted a case study and so this thesis only looked at one professor and the way that he uses the EALBT. I used a case study approach and therefore it is reasonable for there to be one subject however it is accompanied by potential drawbacks. Professor Brown is as far as what could be determined through my literature review, the only instructor who is using this approach of the EALBT and therefore there are no comparisons to how other instructors use this instructional approach. There are, however, instructors that use morphemic approaches, and therefore future studies could compare those instructional methods against the data collected in this study to get an overview of morphemic instruction and its effects on the scientific literacy of students in university classrooms. As I have discussed in my EALBT analysis, there could be other forms to this instructional approach that are not analysed here as they are not used by Professor Brown. Some of this instructional approach seems to be linked to his teaching style, and therefore a future instructor with a different style might use the EALBT differently.

As a secondary limitation, this thesis looked solely at interactions for in class participants. I was provided videos from a 2018 session of Animal Form and Function as taught by Professor Brown, and therefore this course was conducted completely in person (all students taught were physically in the classroom). Online classes have since become more prolific and so exploring how the EALBT would work (or if there would be any differences in its application) for an online medium could be a direction for this research.

I explored professorial instruction in the classroom rather than its effect on students, and therefore a limitation to this thesis is that we do not see the implications on the part of the students. I did not investigate whether students experience positive effects or an increase in metacognition due to the use of the EALBT and its metacognitive aspects of instruction,

although there is indication that students enjoy the instructional approach (Brown, 2014). This limitation was additionally addressed through the use of my categorization matrix for the metacognitive aspects of instruction. I used previously studied metacognitive instructional techniques that had found some increase in the metacognitive abilities of students as a means of finding metacognitive aspects of instruction that have been explored as beneficial to students.

There may be issues of generalizability due to the subjective nature of case studies (Hamel et al., 1993). This study analysed the instructional approach of one professor, Professor Brown, as he taught in his classroom. The methods a professor uses are linked to their strengths and weaknesses regarding their classroom behaviour (Tan, 2011). Therefore, I do not mean to suggest that the metacognitive promoting instructional techniques that are used by Professor Brown in his courses are exhaustive of all possibilities but that they represent a sample of those seen to be effective by him in his courses alone.

This study focused on observational data from the instructor, as I explored an instructional tool and its metacognitive aspects. Studies conducted on metacognitive interventions look at the results as they apply to students; however, this study focused mostly on the procedure for the metacognitive intervention and potential applicability for professors. The focus on procedure produced qualitative data which could pose a potential limitation for this study due to the lack of quantitative data. The use of qualitative content analysis will be used to address this limitation (Kohlbacher, 2006) as it is used to quantify verbal data.

For my analysis, I had to transcribe cases of the EALBT. One of the potential limitations with transcription is the potential loss of information. Verbal data contains information through body language and through inflection in voice which can be important to give context to a transcription (Kowal & O'Connell, 2014). Although I made every effort to transcribe inflection and body movements, there is still a limitation that some context is lost when moving from verbal data to text data.

In this thesis, I focused on how a professor uses an instructional approach and the metacognitive aspects of instruction that are used during this approach. I did not investigate potential increases in metacognition in students when taught vocabulary using the EALBT. There is not one widely adopted way to measure metacognitive strategy use, however there are tests that can be used such as the self-report tool the Metacognitive Awareness Inventory [MAI] (Harrison & Vallin, 2018) in future studies.

There are some aspects to metacognitive instruction as presented by Ellis et al. (2014) that were not measurable for the scope of this study. Engaging curriculum, which integrates student interests into instruction was not found in my dataset as I did not have a way of exploring student interest by observing instructor techniques (Leutwyler, 2009). A professor using an engaging curriculum to encourage the metacognitive abilities of their students can also provide opportunities to practice metacognition for their students. When presenting a term, Professor Brown (or a future instructor trying this instructional approach) could introduce the novel word to his students and then allow them a few minutes to break down the term or to try and identify potential replacement terms. They could then work in groups of two, or as a class to identify the meaning of the morphemes. Small classroom discussions have benefits to students in large classes as it increases their engagement in the classroom, which is beneficial for their understanding (Murphy et al., 2009).

There are drawbacks to using the EALBT in this way. This facet might potentially use more classroom time than some of the other forms of the EALBT (such as the explanatory or visual forms) as the students would need to be given a few minutes to identify the meaning of the morphemes, and then a few more minutes to have a classroom discussion about their ideas. There could additionally be different streams of thought as to when it could be appropriate to use this form of the EALBT, near the beginning of the course, when students would need additional practice, or near the end of the course, when they would have more morphemic knowledge, and be able to use the EALBT with a potentially higher success rate.

There are additional approaches that I did not observe used in this study that could be used by future instructors if they are more suited to their style. Davis (2016) suggests using a bookending method for explicit metacognitive instruction in which an instructor mentions that they will be using a metacognitive method of instruction and that it has certain benefits for students (which they then explain). Davis explains that this explicit instruction primes students for metacognitive instruction and makes them increasingly receptive to potential metacognitive benefits. Once the metacognitive intervention is conducted (i.e., questionnaire, or instructional method such as a case of the EALBT) the instructor could additionally complete the bookending either by asking students what they learned or whether they had any questions/difficulties with any of the material. Bookending is just one way of using explicit strategy instruction (in addition

to the ones I identified to be used by the instructor studied) and therefore instructors can find approaches that best suit their style or classroom needs.

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Appendix A

Master term list compiled from term lists provided by the instructor, and the etymological roots of each term and some examples of term explanations

Term	Etymological roots				
phyla	phylon				
ammonia	ammon				
urea	ouron				
urine	ouron				
tissues	texere				
beetles	bitan				
buoyancy	boya				
size	sedere				
feeding	fedan				
toxic	toxic				
reptiles	repere				
gills	gill				
Mollusca	mollis				
buoyancy	buoy				
gravity	gravis				
alveoli	alveolus				
nutrients	nutrire				
class	classis				
family	famulus				
species	specere				
domain	domanium				
clade	klados				
organs	organum				
anus	anus				
systematic	systema				
Phylum	phylon				
Genus	gene				
Anterior	ante				
Posterior	post				
Zygote	zygote				
Blastula	blasto				
Gastrula	gaster				
Coelom	coel				
cilia	cilia				
test	testa				
toxins	toxic				
vacuole	vacuus				

ampulla	ampulla				
sponges	spongia				
organelles	Organum				
Rhizaria	rhizo				
Flagella	flagellatus				
Stigma	stigma				
Pellicle	pellis				
Silica	silex				
Ciliate	cilia				
Alveola	alveolus				
Plasmodium	plasma				
Spongin	spongia				
Flagellum	flagellatus				
Ostium	oss				
Mesohyl	meso				
Gemmules	gemma				
medusa	medousa				
coral	korallion				
Spicules	spiculum				
Calcium	calc				
Cilium	cilia				
Anemone	anemone				
Gonad	gonos				
Acontia	akon				
Rhopalium	rhopalon				
Ocellus	oculus				
Planula	planus				
Strobila	strobile				
Strobilization	strobile				
Ephyra	ephura				
Pedalium	pedicellus				
Manubrium	manus				
Velum	velum				
Thecate	thica				
testis	testis				
penis	penis				
spine	spina				
mucus	mucus				
Planaria	planus				
Pharynx	pharynx				

Auricle	auris				
Ovary	ovum				
Vitellaria	vitellus				
Uterus	uterus				
Tegument	tegere				
Cercaria	kerkos				
Scolex	scolex				
Rostellum	rostrum				
Cirrus	cirrus				
Coracidium	coracidium				
Bothrium	borthrion				
beak	beccus				
reef	riff				
rectum	rectum				
colony	colonia				
Ciliated	cilia				
Caecum	caecum				
Cystid	cystidea				
Avicularia	avis				
Pedicel	pedicellus				
Mandible	mandibula				
mantle	mentelen				
foot	fot				
proteins	protos				
torsion	torsio				
valve	valva				
circulation	circulus				
sinus	sinus				
blood	blod				
venom	venenum				
stomach	stoma				
kidney	kidenere				
retina	rete				
lens	lens				
cornea	Cornu				
iris	iris				
Fossorial	fossus				
Benthos	benthos				
Radula	radere				
Nephridium	nephro				

setae	seta				
gizzard	gicerium				
testes	testis				
cuticle	cutis				
chitin	khiton				
leeches	laece				
intestine	intus				
Siphon	sipho				
Errantia	err				
Sedentaria	sedere				
Septa/um	saepes				
Capillaries	capillus				
Clitellata	clitellum				
Clitellum	clitellum				
Ovaries	ovum				
molting	molt				
abundance	abundare				
aphid	aphid				
cortex	cortex				
Cloaca	cluo				
Papillae	papilla				
Phasmid	phasma				
Bursa	Bursa				
tagma	tagma				
seta	seta				
wax	waex				
lipid	lipos				
femur	femur				
patella	patella				
tibia	tibia				
sternum	sternon				
dorsal	dorsum				
pincers	pincier				
tail	taegel				
trunk	truncus				
eye	eage				
antenna	antemna				
maxilla	maxilla				
rostrum	rostrum				
labyrinth	laburinthos				

labium	labium				
cicada	cicada				
nymph	nympha				
larva	larva				
pupa	pupa				
cocoon	coccum				
abdomen	abdomen				
Tagmatization	tagma				
Thorax	thorax				
Cuticle	cutis				
Sclerification	sclero				
Molting	mutare				
Carapace	carapace				
Chelicera	khele				
Coxa	coxa				
Trochanter	trochanter				
Tarsus	tarsos				
lamellae	lamina				
Sensilla	sensus				
Stercoral	stercus				
Necrotic	nekros				
Pereon	perion				
Pleon	pleon				
Ocelli	oculus				
Labrum	labrum				
Spiracles	spirare				
Cercus	cercus				
Trachea	trachea				
Tracheoles	trachea				
Rhabdom	rhabdos				
gonads	gonos				
urchins	hericius				
calyx	kalyx				
Ossicles	oss				
Pinnules	pinna				
Cirri	cirrus				
Glomerulus	glomus				
Chordata	chorda				
Atrium	atria				
lamprey	lambere				

canal	canalis				
poros	porus				
vertebrae	vertere				
lamella	lamina				
vein	vena				
lumen	lumen				
bile	bilis				
Predators	praedari				
Denticle	dens				
Dentine	dens				
Arteries	arteria				
Pharynx	pharynx				
Nephrons	nephro				
ossicles	oss				
centrum	centrum				
medulla	medulla				
larynx	larynx				
hormone	hormon				
climax	climax				
liver	liver				
vocalization	vox				
Cecilians	cecil				
Dermis	derma				
Cerebellum	cerebrum				
Cerebrum	cerebrum				
Tympanum	timpani				
Columella	collumella				
Territoriality	terra				
Pylorus	pylorus				
Duodenum	dueodeni				
caffeine	coffee				
alcohol	alcohol				
Amnion	amnos				
Chorion	khorion				
Allantois	allantoeides				
Vitellus	vitellus				
Plastron	emplastrum				
Olfaction	olfacere				
Radiation	radius				
feather	feder				

vane	fane				
hook	hoc				
skeleton	skellein				
predator	praedari				
prey	preie				
Rachis	rhakhis				
Calamus	calamos				
Barb	Barbula				
Barbule	Barbula				
Hamulus	hamus				
Keratin	kera				
Furcula	furca				
Ventriculus	venter				
Ureter	ouron				
nipple	neble				
incisor	incisus				
macula	macula				
Vascularized	vasculum				
Sebum	sebum				
Vibrissae	vibrare				
Cistern	cista				
Dentition	dens				
Bronchi	Bronkhia				
Bronchioles	bronkhia				
Helix	helix				
Lobe	lobe				
ossicles	oss				
Cochlea	cochlea				
Aortic	aorta				
Urethra	ouron				
Testicle	testis				
Clitoris	kleitoris				
Vagina	vagina				
Cervix	cervix				
Fetus	fetus				
Brachiation	brakhion				
Mammal	mamma				
Cephalization	cephalo				
Veliger	velum				
Polyp	polypus				

Radiolarian	radius				
Protista	protos				
Rhabdites	rhabdos				
Miracidium	meriakion				
excretion	ex	cernere			
respiration	Re	spirare			
descendants	de	scandere			
excavata	ex	cavare			
Epistome	epi	stoma			
Desiccation	de	siccare			
Ecdysis	ek	Duo			
Eccrines	ec	krinein			
Hyaline cap	hyalinus	cappa			
bacterial origin	bacterium	originem			
Visceral mass	viscera	masse			
Lymphatic fluids	lympha	fluere			
Atrial siphon	atrium	siphon			
Monotremes	monos	trema			
calcareous	calc	eous			
Foraminifera	foramen	ferre			
Plasmasol	plasma	sol			
Nematodes	nema	oid			
Amoeboid cell	amoeba	cell			
Serous glands	serum	glandulae			
sense organs	sentire	organum			
Gastric filaments	gaster	filum			
Seminal vesicle	semen	vesica			
Copulatory organ	copula	organum			
Seminal receptacle	semen	recipere			
Blood coagulation	cogent	blod			
Gastric caeca	caecum	gaster			
Hemal system	hema	systema			
Parental care	parere	caru			
Inorganic	in	organum			
Prokaryote	pro	karyon			
Eukarya	eu	karyon			
Unicellular	uni	cell			
Multicellular	multi	cell			
Autotrophy	auto	trophy			
Heterotrophy	hetero	trophy			

Saprotrophs	sapro	trophy			
Arthropoda	anthron	pod			
Insects	in	secare			
Osmotic pressure	osmos	pressura			
Iso-osmotic	iso	osmos			
Isotonic	iso	tonic			
Hypotonic	hypo	tonic			
Hypertonic	hyper	tonic			
Temperature fluctuations	temperare	fluere			
Microhabitats	micro	habitat			
Homeostasis	homoios	stasis			
Reproduction	re	produce			
Osmoregulation	osmos	regulate			
Locomotion	locus	motion			
Polypeptides	poly	peptide			
Nitrogen	nitre	gen			
Amphibia	amphi	bios			
Uric acid	ouron	acere			
Operculum	operire	culum			
stable temperature	temperare	stare			
amino acid	amine	acere			
domain bacteria	bacterium	domanium			
domain archaea	arkhaios	domanium			
membrane thickness	membrum	thicce			
stimuli detection	stimulus	detegere			
kingdom	king	dom			
cellular organization	cella	organum			
tissue organization	texere	organum			
organ system	organum	systema			
body cavity	bodig	cavus			
super family	super	famulus			
circulatory system	circle	systema			
dorsal side	dorsum	side			
frontal plane	front	planum			
spiral cleavage	cleave	spira			
radial cleavage	cleave	radius			
Taxonomy	taxa	noma			
Phylogeny	phylon	gene			
Sub-Phylum	sub	phylon			
Infra-Class	infra	classis			

Phylogenetic	phylon	gene			
Cladogram	clado	gram			
Homologies	homo	logos			
Analogies	ana	logos			
Homoplasies	homo	plasies			
Cladistics	clado	tics			
Hominidae	homo	nidae			
Plesiomorphie	plesio	morphe			
Apomorphie	apo	morphe			
Autapomorphies	auto	morphe			
Synapomorphies	synap	morphe			
Endoderm	endo	derma			
Mesoderm	meso	derma			
Ectoderm	ecto	derma			
Ventral	venter	alis			
Median plane	medius	planum			
Blastomeres	blasto	mere			
Blastocoel	blasto	coel			
Gastrulation	gaster	lation			
Blastopore	blasto	porus			
Mesoglea	meso	glea			
Diploblast	diplo	blasto			
Acoelomate	a	ceol			
Eucoelomate	eu	ceol			
Protostome	proto	stoma			
Deuterostome	deutero	stoma			
oral groove	os	groeve			
cell membrane	cell	membrum			
amoeba feeding	amoeba	fedan			
ciliate feeding	cilia	fedan			
contractile vacuole	contract	vacuus			
malaria	mala	aria			
Polyphyletic	poly	phylon			
Protozoa	proto	zoion			
Amoebozoa	amoeba	zoion			
Chromalveolata	chromal	alveolus			
Mitochondria	mito	khondros			
Lysosomes	lyso	some			
Cytopyge	cyto	pyge			
Cytoproct	cyto	proktos			

Pseudopods	pseudo	pod			
Photoreceptor	photo	receptor			
Basal body	base	bodig			
Pyrenoid	pyren	noid			
Chloroplast	chloro	plast			
Amoebozoa	amoeba	zoion			
Pseudopodium	pseudo	pod			
Endoplasm	endo	plasma			
Ectoplasm	ecto	plasma			
Plasmagel	plasma	gel			
pseudopodia	pseudo	pod			
Filopodia	filo	pod			
Axopodia	axo	pod			
Cytostome	cyto	stoma			
Cytopharynx	cyto	pharynx			
Micronucleus	micro	nucleus			
Macronucleus	macro	nucleus			
Trichocyst	trich	cyst			
Phagocytosis	phagos	cyto			
Pinocytosis	pinein	cyto			
Acidification	acere	ifier			
Micronuclei	micro	nucleus			
Macronuclei	macro	nucleus			
Ecology	eco	logy			
Phytoplankton	phyto	plankton			
Parazoa	para	zoion			
Multicellularity	multi	cell			
Class Calcarea	calc	classis			
Choanocyte	choane	cyto			
Porocyte	porus	cyto			
Spongocoel	spongia	coel			
Pinacocyte	pinac	cyto			
Mesenchyme	mesos	enchyma			
Osculum	oss	culum			
Dermal pores	derma	porus			
Radial canal	radius	canna			
Choanocyte	choane	cyto			
Digestion	di	gerere			
Monoecious	mon	oikos			
Protandry	proto	androus			

Planktonic larva	plankton	larva			
Micropyle	micro	pyle			
Amoeboid	amoeba	oid			
Archeocytes	archae	cyto			
Totipotency	totus	potent			
Fragmentation	fragment	ation			
Regeneration	re	generare			
Organic compounds	organum	compounen			
coral bleaching	korallion	blaec			
anal pore	anus	porus			
Dioecious	di	oikos			
Planula larva	planus	larva			
Cnidocyte	cnide	cyto			
Cnidocil	cnide	cilia			
Nematocyst	nemat	cyst			
Endodermis	endo	Derma			
Ectodermis	ecto	Derma			
Gastrodermis	gaster	derma			
Epidermis	epi	derma			
Endocytosis	endo	cyto			
Anthozoa	anth	zoion			
Oral disk	os	disque			
Mesentaries	mes	enteron			
Partial septum	saepes	pars			
Pedial disk	pedicellus	discus			
Scyphozoa	scyphus	zoion			
Gastric pouch	gaster	poche			
Sensory lappet	sense	lap			
Statocyst	stato	cyst			
Statolith	stato	lith			
Rhopalian lappet	rhopalon	lap			
Scyphistoma	scyphys	stoma			
Cubozoa	cubo	zoion			
Hydrozoa	hydra	zoion			
Polyp colony	polypus	colere			
Hydranth	hydra	anthos			
Gonangium	gonos	angium			
Perisarc	peri	sarc			
Athecate	a	thica			
Endosymbiotic	edo	symbiosis			

Ctenophora	cteno	phora			
Colloblast	coll	blasto			
Bioluminescence	bios	lumin			
flame cell	flamma	cell			
nervous system	nervus	systema			
sperm duct	sperma	ducere			
genital chamber	genitus	kamara			
penis fencing	penis	defens			
genital pore	genitus	porus			
circular muscles	circle	musculus			
excretory tubes	excrete	tube			
excretory bladder	excrete	bladder			
vertebrate hose	vertebra	hosa			
Trochophore	trocho	phora			
Lophophore	lopho	phora			
Platyzoa	platy	zoion			
Class Turbellaria	turbellae	classis			
Class Cestoidea	cestus	classis			
Flatworms	flat	worm			
Longitudinal muscles	longus	musculus			
Adhesion glands	adhere	glandulae			
Diverticula	divertere	culum			
Pharynx sheath	pharynx	sceath			
Protonephridia	proto	nephro			
Tubule lumen	tube	lumen			
Nephridiopore	nephro	porus			
Cerebral ganglion	cerebral	ganglion			
Retinular cells	rete	cell			
Fission	fissio	tion			
Oviduct	ovum	ducere			
Copulatory sac	copula	sac			
Trematode	trema	ode			
Acetabulum	acetum	bulum			
Vitelline duct	vitellus	ducere			
Microvillus	micro	villus			
Glycocalyx	glykys	kalyx			
Sporocyst	spore	cyst			
Metacercaria	meta	kerkos			
Prohaptor	pro	haptor			
Opishaptor	opisthen	haptor			

Proglottid	pro	glotta			
Ootype	oo	type			
Onchosphere	onchos	sphere			
Cysticercus	cyst	kerkos			
Procercoid	pro	kerkos			
Plerocercoid	plero	kerkos			
Lophozoa	lopho	zoion			
Mesocoel	meso	coel			
Protocoel	proto	coel			
Metacoel	meta	coel			
Cardiac stomach	cardia	stoma			
Pyloric stomach	pylor	stoma			
Polypide	polyp	ides			
Zooecium	zoion	oikos			
Zoarium	zoion	arium			
Bryozoa	bry	zoion			
Statoblast	stato	blasto			
Chitin shell	chiton	scell			
Bugula colony	bugle	colere			
Ovicell	ovum	cell			
mantle cavity	mantellum	cavus			
mucus glands	mucus	glandulae			
labial palp	labrum	palpare			
optic nerve	optos	nervus			
gastric shield	gaster	scild			
visceral ganglion	viscera	ganglion			
Vermiform	vermis	form			
Eucoelomate	eu	coel			
Ctenidia	cten	idium			
Periostracum	peri	ostracum			
Prismatic	prisma	ic			
muscular pharynx	pharynx	musculus			
tubeworms	tube	worm			
Nacreous	nacre	our			
Odontophore	odont	phora			
Radula sac	radula	sac			
Radula membrane	radula	membrum			
Trophic diversity	trophe	divertere			
Ovo-testicle	ovum	testis			
Vas deferens	vas	deferens			

Albumen gland	albus	glandulae			
Pneumostome	pneumo	stome			
Adductor muscles	adduco	musculus			
Esophagus	eosin	phagos			
Pedal ganglion	pedicellus	ganglion			
Incurrent siphon	incurrere	sipho			
Anterior aorta	ante	aorta			
Posterior aorta	post	aorta			
Hemolymph	hema	lymph			
Glochidia	glochid	idium			
Trochophore	trochus	phora			
Cephalopod	cephalo	pod			
Tentacles	tentare	culum			
Branchial heart	brachia	heart			
Chromatophores	chromal	phora			
Photophores	photo	phora			
Segmentation	segment	ation			
Metamerism	meta	mere			
Parapods	para	pod			
Paraphyletic	para	phylon			
Class Errantia	errant	classis			
Parapodia	para	pod			
Notopod	not	pod			
Neuropod	neuro	pod			
Sensorial	sense	al			
Circumpharyngeal	circum	pharynx			
Segmental ganglia	segment	ganglion			
Metanephridia	meta	nephro			
Nephrostome	nephro	stoma			
Coelomic fluid	coel	fluere			
Capillary filtering	capillus	filtrum			
Clade Errantia	errant	clados			
Clade Sedentaria	sedentary	clados			
Class Sedentaria	sedentary	classis			
Calcareous secretions	calc	secernere			
Prostomium	pro	stoma			
Peristomium	peri	stoma			
Buccal cavity	bucca	cavus			
Typhlosole	typh	solen			
Clade Hirudinea	hirundin	clados			

Hematophagy	hema	phagos			
collagen	kolla	gene			
Ecdysozoa	ecdysis	zoion			
Pseudocoelome	pseudo	coel			
Excretory canal	excrete	canna			
Gonopore	gonos	porus			
Ejaculatory duct	ejaculor	ducere			
Pharyngeal muscles	pharynx	musculus			
Renette gland	renis	glandulae			
Renette canals	renis	canna			
Dioecy	di	oikos			
Sexual copulation	sex	colupa			
Parasites	para	sitos			
Filiary worms	filaria	wyrm			
Lymphatic system	lymph	systema			
microfilaria	micro	filaria			
class arachnida	arakhne	classis			
filtration membrane	filtrum	membrum			
venomous spider	venenum	spinnan			
Exoskeleton	exo	skellein			
Hypodermis	hypo	derma			
Epicuticle	epi	cuticle			
Procuticle	pro	cutis			
Endocuticle	endo	cutis			
Exocuticle	exo	cutis			
Prosoma	pro	soma			
Opisthosoma	opisthen	soma			
Pedipalp	pedicellus	palpus			
Order Aranea	araneus	order			
Metatarsals	meta	tarsal			
Epigynum	epi	gyne			
Spinnerets	spin	et			
Anal papilla	papilla	anus			
Coxal glands	coxa	glandulae			
Malpighian tubules	malphigi	tubus			
Foregut	fore	gut			
Midgut	mid	gut			
Hindgut	hind	gut			
Haemolytic	haemo	lytic			
Pedipalps	pedicellus	palpus			

Preabdomen	pre	abdomen			
Postabdomen	post	abdomen			
Order Acarina	arcarus	order			
Haematophagous	haemo	phagos			
Millipedes	mili	pedicellus			
Centipedes	cent	Pedicellus			
Maxillipede	maxilla	Pedicellus			
Cephalothorax	cephalo	Thorax			
Maxillipeds	maxilla	pedicellus			
Pereopods	perion	pod			
Pleopods	plein	pod			
Uropod	ura	pod			
Protopodite	proto	pod			
Endopodite	endo	pod			
Exopodite	exo	pod			
Epipodites	epi	pod			
Endites	end	ite			
Cheliped	chele	pedicellus			
Extensor muscles	extend	musculus			
Flexor muscles	flex	musculus			
Branchial chamber	brachia	kamara			
Antennal gland	antemna	glandulae			
Nephridial canal	nephro	canna			
Forewing	fore	wing			
Hindwing	hind	wing			
Prothorax	pro	thorax			
Mesothorax	meso	thorax			
Metathorax	meta	thorax			
Basalar muscles	basal	musculus			
Synchronous	syn	chronos			
Hypopharynx	hypo	pharynx			
Proventriculus	pro	venter			
Ovipositor	ovum	posit			
Dorsal heart	dorsum	heart			
Dorsal aorta	dorsum	aorta			
Oviposition	ovum	posit			
Predatory coccinellid	coccineus	praedari			
Tracheal system	trachea	systema			
Tracheole fluid	trachea	fluere			
Abdominal ganglia	abdomen	ganglion			

Georeceptor	geo	receptor			
Tympanic membrane	tympanum	membrum			
Tympanal cavity	tympanum	cavus			
Ommatidium	omma	idium			
Cuticular lens	cutis	lens			
Crystalline cone	crystal	konos			
Retinula cells	rete	cell			
Metamorphosis	meta	morphe			
Ametabolous	a	metabolic			
Hemimetabolous	hemi	metabolic			
Holometabolous	holo	metabolic			
Deuterostomia	deutero	stomia			
Pentaradial	penta	radius			
Hemal rings	hema	hring			
Madreporite	madre	porus			
Dermal branchiae	derma	brachia			
Radial nerve	radius	nervus			
Pedicellaria	pedicellus	aria			
Pyloric caeca	pylorus	caecum			
Ciliary band	cilia	bade			
Articulated ossicles	oss	articulus			
Class Echinoidea	echins	classis			
Herbivores	herb	vorare			
Class Holothuridae	holo	classis			
elastic sheath	elaunein	sceath			
acorn worm	aecern	wyrm			
Phylum Chordata	chorda	phylon			
Ambulacraria	amble	cranium			
Notochord	notos	chorda			
Pharyngeal slits	pharynx	slite			
Pharyngeal pouches	pharynx	poche			
Endostyle	endo	style			
Axial skeleton	axis	skellein			
Turgescent cells	turgere	cell			
Fibrous sheath	fibre	sceath			
Proboscis	pro	bosekein			
Branchial pore	brachia	porus			
Collar coelom	coel	collum			
Trunk coelom	coel	truncus			
Zooid	zoion	oid			

Urochordata anatomy	ura	chorda			
Paedomorphosis	paed	morphe			
Cephalochordata	cephalo	chorda			
Buccal cirri	bucca	cirrus			
Atriopore	atria	porus			
class myxini	myxa	classis			
hagfish	hag	fish			
knot feeding	cnotta	fedan			
enamel	en	amail			
anal fins	anus	finn			
frontal bone	frons	ban			
pectoral fin	pectus	finn			
pelvic fin	pelvis	finn			
Cyclostome	cycle	stoma			
Sessile larva	sessile	larva			
Cartilaginous skeleton	cartilage	skellein			
Hydrodynamic	hydro	dynamic			
Ampullary organ	ampulla	organum			
Osteichthyes	osteon	ikhthus			
Pectoral fins	pectus	finn			
Dorsal fins	dorsum	finn			
Caudal fin	cauda	finn			
Pelvic fins	pelvis	finn			
Neuromasts	neuro	mast			
Sensory cells	sense	cell			
Sensory hair	sense	haer			
Ventral rib	vertere	rib			
Dorsal rib	dorsum	rib			
Branchial filaments	brachia	filum			
Gallbladder	gall	bladder			
Pyloric valve	pylorus	valva			
Reabsorption	re	absorb			
mucus gland	mucus	glandulae			
tadpole	tada	poll			
eyelids	eye	lid			
Order Caudata	cauda	order			
Ichthyostega	ichthy	stega			
Undulating movements	undula	movere			
Cervical vertebrae	cervix	vertere			
Sacral vertebrae	sacrum	vertere			

Caudal vertebrae	cauda	vertere			
Apophyses	apo	phyein			
Pelvic girdle	pelvis	gyrdel			
Pectoral girdle	pector	gyrdel			
Appendicular skeleton	append	skellein			
Urostyle	ura	stylos			
Optical lobe	optic	lobos			
Buccal pump	bucca	pomp			
Ventricle	venter	ulus			
Amplexus	amb	plactere			
Prolactin	pro	lactare			
Terrestrial copulation	terra	copula			
Ambush predation	praedari	embusche			
Oesophagus	oisein	phagos			
Nictitating membrane	nicto	membrum			
Order Testudine	testudo	order			
nasal cavity	nasal	cavus			
viper	vivus	parere			
protection	pro	tegere			
Order Crocodylia	crocodilus	order			
Lepidosauria	lepid	sauria			
Archosauria	archo	sauria			
Dinosauria	dino	sauria			
Temporal Fenestrae	tempo	fenestra			
Anapsid	an	hapsis			
Synapsid	syn	hapsis			
Diapsid	dino	hapsis			
Amniotic fluid	amnos	fluere			
Reptilia Tegument	reptile	tegere			
Stratum germinativum	stratum	germinate			
Stratum granulosum	stratum	granulate			
Stratum corneum	stratum	corneus			
Keratinous scales	keratin	scale			
Long rostrum	rodere	long			
Testudines anatomy	testudo	temnein			
Keratinized beak	keratin	beccus			
Thermoreception	thermo	receptor			
Parietal eye	paries	eage			
Vertebrate kidney	vertere	kidney			
Glomeruler capsule	glomus	capsa			

Ectotherms	ecto	thermal			
Poikilotherms	pokilos	thermal			
Convection	con	vehere			
Conduction	con	ducere			
Evapotranspiration	evaporate	transpiration			
Thermoregulation	thermal	regulate			
pancreas	pan	kreas			
adrenaline	ad	renal			
Parabronchi	para	bronchia			
Pygostyle	pyg	style			
Apophyse	apo	phyein			
Tibiotarsus	tibia	tarsus			
Pneumatized bones	pneumo	ban			
Epinephrine	epi	nephro			
Altricial chicks	altric	chick			
Precocial chicks	praecoces	chick			
Mammalia Tegument	mammal	tegere			
Apocrines	apo	krin			
Sebaceous glands	sebum	glandulae			
Erector muscles	erect	musculus			
Piloerection	pilus	erection			
Hard palate	palatum	hard			
Epiglottis	epi	glotta			
Dental formula	dentitio	form			
Premolars	pre	molares			
Heterodonty	hetero	odont			
Diphydont	diphy	odont			
Diaphragm	dia	phrassein			
Auditory tube	audire	torius			
Tympanic cavity	typtein	cavus			
Cochlear nerve	konche	nervus			
Otoliths	oto	lithe			
Gelatinous material	gel	materia			
Pulmonary artery	pulmo	arteria			
Pulmonary vein	pulmo	vena			
Ornithodelphia	ornith	delphes			
Oviparity	ovum	parus			
Metatheria	meta	theria			
Viviparity	vivus	parus			
Marsupials	marsupium	alis			

Abdominal pouch	abdomen	poche			
Eutheria	eustachio	therion			
Embryo	en	bryein			
Chorionic villi	chorion	villus			
Endometrium	endo	metra			
Australopithecines	australis	pithekos			
Triploblast	triplo	blasto			
Adductor muscle	adduco	musculus			
Hepatic caecum	hepa	caecum			
Pennaceous feather	penna	feather			
respiratory system	re	spirare	systema		
Epitheliomuscular	epit	thele	musculus		
Class Trematoda	treama	odes	classis		
Cutaneous respiration	cutis	Re	spirare		
Infra-red detection	infra	de	tegere		
Gonozooid	gonos	zoion	oid		
Gastrozooid	gaster	zoion	oid		
Eukaryotic cell	eu	kary	cell		
Class Asteroidea	aster	oidea	classis		
Annelid phylogeny	anellus	phylon	gene		
Amniota Phylogeny	amniote	phylon	gene		
Mollusca Phylogeny	mollis	phylon	gene		
Root parasites	para	sitos	wrot		
Food vacuole	vacuum	olum	fod		
Ecological niche	eco	logy	nidus		
Transverse fission	trans	versus	findere		
Animal apomorphies	apo	morphe	anima		
Polyphyletic group	poly	phylon	group		
Paraphyletic group	para	phylon	group		
Monophyletic group	mono	phylon	group		
Retractor muscle	re	trahere	musculus		
Predatory polychaete	poly	chaite	praedari		
Reticulopodia	rete	culum	pod		
Digestive glands	di	gerere	glandulae		
Digestive gland	di	gerere	glandulae		
Dorsoventral muscles	dorsum	vertral	musculus		
Order Gymnophiona	gymno	ophonia	order		
Cestode lifecycle	cestus	life	cycle		
Embryonated egg	en	breyin	egg		
Class Petromyzontida	petro	myzon	classis		

Arboreal hypothesis	arbor	hypo	thesis		
Cursorial hypothesis	cursory	hypo	thesis		
Molecular cladogram	mole	clade	gram		
Marine environment	mare	environ	ment		
Osmotic stress	osmos	otic	strictus		
Terrestrial environment	terra	environ	ment		
Metabolic waste	meta	ballein	vastus		
Nitrogenous wastes	nitro	genous	vaste		
Surface ventilation	ventilate	tion	surface		
harsh environments	environ	ment	haer		
animal requirements	anima	re	quaerere		
surface area	sur	face	area		
surface volume	sur	face	volvere		
kingdom plantae	planta	king	dom		
kingdom animalia	anima	king	dom		
kingdom fungi	fungal	king	dom		
digestive system	di	gerere	systema		
Bifurcation of conduits	bi	furca	conducere		
Taxonomic hierarchy	taxa	noma	hierarkhes		
Paraphyletic naming	para	phylon	noma		
Animal phylogeny	phylon	gene	anima		
Ancestral traits	ante	cedere	tractus		
Symplesiomorphies	sym	plesio	morphe		
Embryonic tissue layers	en	bryein	texere		
Reproductive system	re	produce	systema		
Asymmetry	a	sun	metron		
Oral-aboral	oral	ab	oral		
Transverse plane	trans	versus	planum		
Pseudocoelomate	pseudo	ceol	mate		
insect vector	in	secare	vehere		
Endosymbiosis	endo	sym	bios		
Parallel propulsion	para	pro	pulse		
Phagocytotic vacuole	phagos	cyto	vacuus		
Calcium carbonate	calc	carbon	ate		
Phagocytitic vacuole	phagos	cyto	vacuus		
Interciliary fibres	inter	cilia	fibre		
Ciliary locomotion	locus	motion	cilia		
Longitudinal fission	long	fissio	tions		
Sexual reproduction	sex	re	produce		
Choanoflagellate colony	choane	flagellatus	colere		

Specialized choanocytes	choane	cyto	species		
Multicellular organism	multi	cella	organum		
sponge lifecycle	spongia	life	cycle		
Sponge phylogeny	phylon	gene	spongia		
Colonial hypothesis	colony	hypo	tithenai		
Class Demospongiae	desm	spongia	classis		
Porifera architecture	porus	fer	architectus		
Ascon body form	askos	bodig	form		
Sycon body form	sykon	bodig	form		
Leucon body form	leukos	bodig	form		
Excurrent canal	ex	currere	canna		
Amphiblastula larva	amphi	blasto	larva		
Basal phyla	base	al	phylon		
Class Anthozoa	anth	zoion	classis		
Class Staurozoa	stauro	zoion	classis		
Class Cubozoa	cubo	zoion	classis		
Class Scyphozoa	scyphus	zoion	classis		
Class Hydrozoa	hydro	zoion	classis		
Hydrostatic skeleton	hydro	staticus	skellein		
Nematocyst capsule	nemat	cyst	capsa		
Nematocyst tube	nemat	cyst	tube		
Gastrovascular	gaster	vas	culum		
Oral tentacles	oss	tentare	culum		
Complete septum	saepes	com	plere		
Ciliary ventilation	cilia	ventus	ilare		
Zooxanthellae	zoion	xanthos	ella		
Ciliated locomotion	cilia	locus	motion		
Gastrovascular canals	gaster	vascula	canna		
Lophotrochozoa	lopho	trocho	zoion		
Class Monogenea	mono	genea	classis		
Endoparasites	endo	para	sitos		
Ectoparasites	ecto	para	sitos		
Parenchyma	para	en	chein		
Protective mucus	pro	tegere	mucus		
Digestive cavity	di	gerere	cavus		
Chemosensory reception	chem	sense	recipere		
Photoreception	photo	re	capio		
Anterior zooid	ante	zoion	oid		
Posterior zooid	post	zoion	oid		
Cytoplasmic bridge	cyto	plasma	brug		

Monogenea flukes	monos	genea	flook		
Cestode tapeworms	cestoda	tape	worm		
Tripartite coelom	tri	partitus	coel		
Lophophore tentacles	lopho	phora	tentare		
Epidermal secretions	epi	derma	secernere		
Asexual budding	a	sex	bud		
Budding polypide	polyp	ides	bud		
Class Caudofoveata	caudal	fovea	classis		
Class Solenogastres	solen	gaster	classis		
Class Gastropoda	gaster	pod	classis		
Class Cephalopoda	cephalo	pod	classis		
Class Bivalvia	bi	valva	classis		
Class Scaphopoda	scaphe	pod	classis		
Pericardial cavity	peri	cardia	cavus		
sperm transfer	sperma	trans	ferre		
Excurrent siphon	ex	currere	sipho		
Parasitic larvae	para	sitos	larva		
Digestive caecum	di	gerere	caecum		
Annelid Taxonomy	annelus	taxa	noma		
Class Polychaeta	poly	chaite	classis		
Class Oligochaeta	oligo	chaite	classis		
Class Hirudinida	hirundin	idea	classis		
Clade Clitellata	clitellum	ata	clade		
Hydrostatic compartments	hydro	static	compartiri		
Suprapharyngeal ganglion	supra	pharynx	ganglion		
Subpharyngeal ganglion	sub	pharynx	ganglion		
Prostomium sensorial	pro	stoma	sentire		
Sub-class Hirudinea	hirundo	sub	classis		
Calciferous glands	calc	ferous	glandulae		
Chloragogen cells	chloro	agogos	cell		
Clitellata copulation	clitellum	ata	copula		
Metameric segments	meta	mere	secare		
Proboscis pore	pro	bosco	porus		
Anti-coagulant saliva	anti	cogent	saliva		
Nematode phylogeny	nema	phylon	gene		
cryptic biology	kruptos	bios	logy		
Renette cells	renes	ette	cell		
Protoplasmic extensions	proto	plasma	extend		
Rhabditiform larva	rhabdos	form	larva		
Filariform larva	filaria	form	larva		

Hematophagous insect	haemato	phagos	secare		
class insecta	in	secare	classis		
Serial appendages	series	append	age		
Subphylum Crustacea	sub	phylon	crustacea		
Secretion of epicuticle	secrete	epi	cuticle		
Class Merostomata	meros	stoma	classis		
Genital operculum	op	culum	genitus		
Gill operculum	op	culum	gill		
Order Scorpionida	scorpio	ida	order		
Class Diplopoda	diplo	pod	classis		
Class Chilopoda	chilo	pod	classis		
Prothoracic leg	pro	thorax	leggr		
Mesothoracic leg	meso	thorax	leggr		
Metathoracic leg	meta	thorax	leggr		
Asynchronous	a	syn	chronos		
Parasitoid wasp	parasite	oid	waesp		
Hydrophobic hairs	hydro	phobe	haer		
Protocerebral ganglia	proto	cerebral	ganglion		
Trichromatic vision	tri	chromal	videre		
Gradual metamorphosis	meta	morphe	gradus		
Ambulacral groove	amble	crum	groeve		
Ambulacral locomotion	amble	locus	motio		
Bipinnaria larva	bi	pinna	aria		
Brachiolaria larva	brachia	aria	larva		
Ophiuroidea	ophis	ura	oidia		
Aposematic colouration	apo	sema	colorare		
Class Crinoidea	krinon	oidea	classis		
Phylum Hemichordata	hemi	chorda	phylon		
dorsal tubular nerve	dorsum	tube	nervus		
Class Enteropneusta	enter	pneusta	classis		
Class Pterobranchia	pteron	brachia	classis		
Sub-phylum Craniata	sub	phylon	cranium		
Post-anal tail	post	anal	taegel		
Thyroid gland	thyra	oid	glandulae		
Buccal diverticulum	bucca	divert	culum		
Tripartie coelom	tri	partitus	coel		
Proboscis coelom	pro	bosekein	coel		
Infra-Phylum Vertebrata	infra	phylon	vertebrate		
Class Chondrichthyes	chondria	ikhthus	classis		
Class Actinopterygii	actino	pteron	classis		

Class Sarcopterygii	sarco	pteron	classis		
Paraphyletic classes	para	phylon	classis		
Monophyletic clades	mono	phylon	klados		
Sensory tentacles	sense	tentare	culum		
Actinopterygii skeleton	actin	pteron	skellein		
Premaxillary bone	pre	maxilla	ban		
Order Anura	an	ura	order		
Sarcopterygii	sarco	pteron	fish		
Terrestrial locomotion	terra	locus	motion		
Zygapophyses	zygo	apo	physis		
Saltatory locomotion	saltatorius	locus	motion		
Olfactory lobe	olere	facere	lobos		
Buccopharyngeal pump	bucca	pharynx	pomp		
Gelatinous eggs	gelatine	ous	egg		
Premetamorphosis	pre	meta	morphe		
Caudata reproduction	caudal	re	produce		
Anura feeding	an	ura	fedan		
Order Squamata	squam	ata	order		
Cardiovascular endurance	cardio	vascular	indurance		
Vomeronasal organ	vomer	nasal	organum		
Unfused mandibles	un	fuse	mandere		
Articulated maxillary bone	articulus	maxilla	ban		
Descending limb	de	scandere	lim		
Ascending limb	a	scandere	lim		
Diuretic drinks	dia	ouron	drincan		
Thoracic air sacs	thorax	aer	sac		
Abdominal air sacs	abdomen	aer	sac		
Carpometatarsus	carp	meta	tarsas		
Tarsometatarsus	tarsus	meta	tarsus		
Binocular vision	bi	ocular	videre		
Shell gland cloaca	cloaca	scell	glandulae		
Major Histo-compatability complex	histo	compatible	magnus		
Adipose tissue	adip	oss	texere		
Inter-costal muscles	inter	costal	musculus		
External auditory canal	exter	audire	torius		
Semi-circular canals	semi	circle	canna		
Epididymis	epi	dyo	didymos		
Seminiferous tubules	semen	iferous	tube		
Prostate gland	pro	histo	glandulae		

Bulbo-urethral gland	bulbo	ouron	glandulae		
Arboreal ancestors	arbor	ante	cedere		
Dorsoventral muscle	dorsum	verticle	musculus		
Evolutionary relationships	evolve	latus	re		
Vestigial polypide	vestige	ides	polyp		
Ciliated chemoreceptive cells	chem	receptor	cilia	cell	
Class Homoscleromorpha	homo	sclera	morphe	classis	
Biochemical transformation	bios	chem	form	trans	
Cnidarian phylogeny	cnide	aria	phylon	gene	
Protista phylogeny	pro	tist	phylon	gene	
Platyhelminthes phylogeny	platy	helminth	phylon	gene	
Arthropoda phylogeny	anthro	pod	phylon	gene	
Arthropoda Taxonomy	arthron	pod	nomy	taxa	
Perpendicular propulsion	pulse	pendere	pro	pulse	
Extra-corporal digestion	extra	corporal	di	gerere	
Binomial nomenclature	bi	noma	noma	clature	
Bilateral symmetry	bi	lateral	sun	metron	
Embryonic development	en	breyin	dis	envelop	
Endoplasmic reticulum	endo	plasma	rete	culum	
Digestive enzymes	di	gerere	en	zume	
Asexual reproduction	a	sex	re	produce	
Coenocytial hypothesis	coeno	cyto	hypo	thesis	
Bilateral ancestor	bi	latera	ante	cedere	
Parenchymula larva	para	en	chein	larva	
Flagellar ventilation	ventus	ilare	tio	flagellatus	
Extracellular digestion	extra	cell	di	gerere	
Intra-cellular digestion	intra	cell	di	gerere	
Dorso-ventral muscles	dorsum	venter	alis	musculus	
Trematode lifecycle	trema	ode	life	cyclus	
Freshwater Bryozoa	bry	zoion	fresh	water	
Class Polyplacophora	poly	plac	phora	classis	
Class Monoplacophora	mono	plac	phora	classis	
Sinusoidal locomotion	sinus	oid	locus	motionem	
Sub-class Oligochaeta	olig	chaite	sub	classis	
Peristaltic locomotion	peri	stel	locus	motion	
Epidermal glandular cells	epi	derma	glandulae	cell	
Sub-Phylum Chelicerata	sub	phylon	chele	ata	
Sub-Phylum Myriapoda	sub	phylon	myria	pod	
Sub-Phylum Hexapoda	sub	phylon	hexa	pod	

Biramous appendages	bi	ramus	append	age	
Supraesophageal ganglion	supra	eosin	phagos	ganglion	
Subesophageal ganglion	sub	eosin	phagos	ganglion	
Haplodiploid sex determination	haplo	diplo	sex	determinare	
Sub-phylum Urochordata	sub	phylon	ura	chorda	
Sub-phylum Cephalochordata	sub	phylon	cephalo	chorda	
Metameric myomeres	meta	meros	my	mere	
Infra-Phylum Hyperotreti	infra	phylon	hyper	treti	
Super-Class Gnathostomata	nath	stomata	super	classis	
Amphibia Taxonomy	amphi	bios	taxa	noma	
Super-Class Tetrapoda	super	classis	tetra	pod	
Proximal convoluted tubule	proximus	con	tubus	volvere	
Distal convoluted tubule	distant	con	volvere	tubus	
Anti-diuretic hormone	anti	dia	ouron	hormone	
Super-order Paleognathae	super	order	paleo	gnathae	
Super-order Neognathae	super	order	neo	gnathae	
Archaeopteryx lithigraphica	archae	pteron	lith	graph	
Infra-Class Ornithodelphia	infra	classis	ornith	delphes	
Infra-Class Metatheria	infra	classis	meta	theria	
Infra-Class Eutheria	infra	classis	eu	therion	
Bipedal locomotion	bi	pedicellus	locus	motion	
Lophotrochozoa phylogeny	lopho	trocho	zoion	phylon	gene
Secondary bilateral symmetry	second	bi	lateral	sun	metron
Class Hexactinellida	hexa	Actin	ella	ida	classis
Sub-Phylum Trilobitomorpha	sub	phylon	tri	lobe	morphe

Appendix B

Full transcripts of each case of the EALBT for the 7 classes chosen for the dataset

Sarcoplasm

I don't know if you remember when we were playing the identify the etymological roots game and we were in the process of making root matches with the root of *sarco* (Pointing out to crowd). Who was it that mentioned *sarcomere*? Because you know when you brought up, no sorry it wasn't *sarcomere* it was *sarcoplasm*, right? And I just wanted to point out that you were right, and I was confused and so that's why because afterwards I was like "What's nagging me about this?" and when you suggested *sarcoplasm*, I kind of oriented the discussion towards *sarcomere*, because something was going wrong in my head, I was thinking of *sarcoplasmic reticulum* and I couldn't mesh the two things. You're absolutely right that the *sarcoplasmic reticulum* is a thing and I just wanted to point out that you were right and that I was confused. Alright? So just to clear that up, because I don't want any misgivings of me saying you're wrong when you're not, I think I didn't say that, it makes a lot of sense just in terms of the root, *plasm* being a liquid and *sarco* meaning the liquid in the cells of a particular type of muscle and so I just wanted to follow up on that, and that it's normal that we as professors don't know absolutely everything, and my field is not physiology so there are some of these terms that are less familiar to me than others, I just wanted to bring up that this notion of using the etymology to sort of point to different words is very useful, and you made more use of it at that time.

Binomial Nomenclature

Now one thing that I want to point out here as we're looking at it, this naming system that we have for species is a two-name system and that two-name system also has a name which is *binomial nomenclature*. So, I'm glad to see that they brought me my chalkboard, because we're going to be using it. I'm going to write it for you, but I'm pretty sure that it appears somewhere within the next slide or two as a name. But I just wanted to write it so we can discuss it so it's clear that this. "*Binomia-*" (writes on chalkboard). I can't write and talk at the same time, I don't know what this limitation is (writes), There we go. So, this *binomial nomenclature* is the way that we name species but interestingly as a term it's quite redundant because *binomial* means "two names" and *nomenclature* means "to name something". So *binomial nomenclature* means to name things with two names and that's how we do it.

Polyphyletic

Such as if we were to group them all together 1-8 and call them a name - it would be called a *poly-phyletic* group if they were all in the same group it would be called *polyphyletic*. Now let's get back to the etymology of these words, what would *polyphyletic* mean? The *phylogeny* means the evolutionary lineage and *poly* means several. So here were grouping several evolutionary lineages together without the fact that they shared a common ancestor, they don't even share a common ancestor, they're widely disparate lineages and we grouped them together, that would be *polyphyletic* and that would be wrong.

Cephalization

Now you will note that up in this top corner we have another bilaterally symmetrical animal, a longhorn beetle that I have put up there with the *cephalization* to indicate that bilateral symmetry is a consequence of this process this developmental evolutionary process known as *cephalization*. Now again, etymology is at the root of our understanding of all of these terms, what's a *cephalize*, anyone, yes? (Class murmur). A head yes! Anything to do with a head and with the brain as well, so basically cephalization is the process of developing a head.

Gastrulation

So, what we're seeing here in this space that's covered by red on the inside will eventually become that digestive tract that runs into the animal and that therefore, this process of creating this gastric tract is known as *gastrulation*. *Gastru* as a term refers to sort of stomach or intestines, *gastrulation* is the process of forming that and it starts with the infolding or invagination fo that blastula and once it does invaginate and start to form the digestive tract or this gastric cavity it becomes known as a *gastrula*. So it really just changes names, it starts as a blastula and then once the process of *gastrulation* starts we then call it a gastrula because it's changed somewhat.

Diploblastic

And this is also known as a *diploblastic* body plan, *diplo* meaning two, *blast* referring to the embryonic germ layer of tissue, so there's only two in the more simple tissue composed animals, they're *diploblastic* because they only have endoderm and mesoderm.

Acoelomate/Pseudocoelomate

If it does not have a coelom within those body tissues, it's known as *acoelomate*. *A*- as a prefix meaning absence of absence of a *coelom*. So those *acoelomate* animals are solid with material there's no fluid filled cavities within them apart from that empty space that's a part of

the gut. If we're to skip the *pseudocoelomate* for now and talk about *eucoelomate* because it makes a little bit more sense when we do it in this order a *eucoelomate* as the prefix suggest as the true *coelomates*, *eu* refers to the true *coelomates*, meaning that they have the true cavities within their bodies and in order to qualify as a true *coelom* it has to be completely lined by mesoderm, meaning that that cavity is directly within the mesoderm tissue and that would be a true *coelom*.

Monoecious/Dioecious

So, as a reminder generally speaking these higher classes of *cnidaria* are *dioecious* species, right? Meaning they are not hermaphrodite or *monoecious* they in fact have two different sexes being male and female. I don't remember if I wrote that word for you, so I'll do it again just in case it is something that I haven't explicitly identified yet, but of course if we remember the etymology of *monoecious* that means *mono oikos* meaning one house and *dio-oikos* meaning two houses. So, *di-o-e-ci-ous* (sounding out as writing on blackboard) is how we describe organisms that have one of two sexes, so male or female.

Gonozoid

If it is to be a reproductive polyp it will be known as a *gonozoid*, *gono* referring to the reproductive units, *zoid* to the little animal and also the synonymous aspect of this is *gonangium* in singular and gonangia in plural if there are more than one of these things on a single colonial unit.

Thicate

So, the fact that this particular life cycle is demonstrating an example of a colony that has this perisarc and is sort of enclosing these polyps in a sort of enveloppe or rigid structure makes these colonial polyps a *thicate* polyp. And you'll remember this root, *thica,* that we had talked about on the very first day, in particular that there's a couple of French words that employ it, whereas it's not quite as common in English. *Thica* meaning what again please? (Class murmur). A housing, right? Because of say 'le mot pour ou on met les livres le biblioteche' right so biblioteche or discoteche meaning a housing or a case that surrounds something, in that case books or dancers if you will at the discotheque. So, a *thicate* means that there is an envelope some sort of case around them, and this is important to note, well it's important to note that not all colonial polyps of the class *hydrozoa* are *thicate*, in some instances they don't secrete this perisarc and live within a case.

Platyhelminthes

Ok, so as usual we like to see that the words in all of these cases means something it's not just a random assemblage of letters and so this phylum which is known as *platyhelminthes* is made up of two root terms *platy* and *helminthe*. Now I don't know if *helminthe* is a term that is very well known, it's now commonly used in our English parlance on a day-to-day basis, it used to be a lot more common as a term that we would use to describe a certain kind of animal. Does anybody know what that would be? (Class murmur) A worm that's right, and *platy* referring to? (Class murmur) Flatness right! So, these are the flatworms, so *platy helminthes* means the flat worms.

Lophotrochozoa

So, what we'll be focusing on today and for the next couple of lectures will be those that are found within this clade known as the *lophotrochozoa*. Now as a term, understandably it doesn't seem to refer to much but it should become clear what *lophotrochozoa* means in particular when we see that it refers to either having a *lophophore*, which is what this is (laser points to the projector screen) a ring of tentacles around the mouth, and *phora* meaning having something or bearing something a *lopho* is a crown, so it is bearing a crown and its crown is made of tentacles. But that's the origin of this name.

Protonephron

So, they need a mechanism to expel a surplus of water that they're just going to be constantly taking on. That mechanism that satisfies this osmoregulatory role involves a series of canals and structures known as *protonephridia*, this term here should be recognizable to us. *Proto* and *nephron*, *nephron* referring to? (Class murmur) Sorry? (Class murmur) The kidneys, right? *Proto*? (Class murmur) The First! So, here's sort of our first sort of kind of kidney which is a structure which filters the internal fluids in order to expel the waste to the outside.

Spermatophore

Males transfer the sperm, but they transfer it in a package which is known as a *spermatophore*. (writes on board) So you will recognize this suffix *phora* which means to bear or to contain something and it bears sperm! But it also has other stuff, so *spermatophores* are packages that contain sperm that are transferred between males and females.

Hemocyanin

In cephalopods, they have evolved into a pigment to transfer respiratory gasses, our pigment in our blood cells being hemoglobin is a characteristic of vertebrate respiratory pigment. In the cephalopods it is *hemo* (writing) *cyanin* (writing) so *cyanin* is a molecule that gives blueness to color. *Hemo,* referring to blood but this is, but the blood of cephalopods is a little more blue-ish because of the pigments that they have, and the pigments are dissolved directly into the plasma.

Annelid

We'll talk about *annelids*. So, *annelids* as all other animals have a name that means something. So, what is this name, what's an *annelid,* and of course as a term it might be more similar to a word in French than in English, but hey! We're bilingual here at the University of Ottawa! What does *annelid* mean? Des *anneaux* c'est quoi? (Class murmur) with rings! That's right. So, an *anneaux* is a ring, an *annelid* is a ringed animal, so what we're talking about is it's a segmented animal, so segmentation is the key for this phylum *annelida*, and so obviously that's going to be a very important feature that distinguishes them

Polychaeta

The first being class *polychaeta* and the *polychaetes*, *cheta* refers to small little sensory like hairs or rigid structures also *seta* as we shall see in the slides is synonymous with *cheta* so whether is has an *s* or a *ch* its the same thing and *poly* meaning several so the *polychaetes* are these free-living worms

Notapod

The dorsal lobe is more the area where there is gas exchange, and that dorsal lobe is known as the *notapod* and *notem* or *nota* refers to anything that is dorsal, and I'll just write that here "*notapod* is dorsal" (writing) portion of the parapod or parapodia

Protopodite

We recognize that each of these appendages are attached to the body via a basal segment and that basal segment is the *protopodite*, meaning the first aspect of the little leg, *podite* meaning 'little leg' and *proto* meaning 'the first' and so the point at which it attaches to the body is the *protopodite* but because these are biramous appendages after that *protopodite* there will be two branches that come off typically, and those two branches will either be a medium branch, which means towards the middle.

Lepidoptera

Most adult *lepidoptera* which is the group of insects that includes the butterflies and moths and again, just as a point of interest, remember I said the insect orders are named after the morphology of the wings being *ptera* part. *Lepidoptera* means the scaly wings, alright?

Parasitoid

And I'm saying *parasitoid* as a word that is distinctly different from a parasite because a *parasitoid* which I'll write for you now, is like a parasite, which is what the suffix *oid* refers to. *Oid* means its 'like something', and its like a parasite and the reason it's not a parasite via the biological definition is because a *parasitoid* is only parasitic at one stage in its life cycle and usually the stage in the life cycle that's parasitic is the larval stage.

Enteropneusta

Alright! So next let's look at our first phylum hemichordata and the first class of these *enteropneusta* well*," p"neusta*. We don't usually pronounce the *p*, but we recognize perhaps those root words, right? *Entero* right? And *pneusta*? Perhaps *entero* is not one that's as common but it refers to the gut or the intestine and *pneusta* obviously has the same root and *pneumo* referring to a lung, right? So essentially what were referring to is a lung interesting, and I think what this is referring to is the intestine does also play a role in respiration so we should be able to understand that in a minute or two once we sort of go through the internal anatomy.

Pterobranchia

So, that is it, so let's move on to the second class within our phylum *hemichordata*, class *pterobranchia*, in which we have ptero-branchia being the root words and we know these root words already. What is a *pteron*? Someone says it please out loud. (Class murmur) A wing! And *branchia* refers to? Someone please? It sounds like it's related to the heart because it has elements associated with the circulatory system but the branchia refers to... it plays a similar role as lung, but in more primitive organisms the gas exchange organs are? (Class murmur) Gills! So *branchia* means gills. So, think for example, there's a branchial heart in cephalopods which is a pumping organ that increases the pressure of the blood as it flows through the cnidia, which is its gills. So, these sorts of etymological links should be accessible to us and be able to be used as a means to demystify the words and not have to memorize them.

Urochordata

And of course, hopefully this should help us to understand the name of this subphylum *urochordata*. What does *uro* mean, anyone? Have an idea? I heard a whisper, but I can't make

out what it is when I just hear (chittering). (Class murmur) It is a tail! It's in fact Greek for tail, and Latin for tail is *cauda* or *caudal*, and so *uro* is not used as frequently as *cauda*, but it means tail! So, look at the name *urochordata* means that the characteristics that are missing to help it be defined as a *chordate* are found in the tail which are in the larvae of the life cycle. So again, all of these things mean something and if we can just look at the name it will point towards the structure and function and help us to remember what we're looking at to decrease that requirement to memorize and hopefully be useful to our studies here but also in you know in science as well.

Amphibian

Alright so today we're going to be talking about *amphibians*, and again etymology as ou**r** guide, *amphi - bio* means 'double life'. *Biology* is the study of life and *amphi* means that its double, and its double because these are the organisms that live both in water and outside of water, they don't live truly in either and that they are most specifically restricted in dry land because they lack adaptations that would prevent them from desiccating particularly with respect to their own skin and also specifically with respect to the reproductive elements with the gamete and the eggs being susceptible to drying out so they need to return to water occasionally meaning they live this double life being both terrestrial and aquatic.

Gymnophonia

But getting back to talking about the *gymnophiona*, they are limbless, they are lacking their appendages for the locomotory appendages so they're very snake like and so the name *gymnophiona*. *Ophiona* means a 'snake' and *gymno* means 'naked'. Isn't that strange? Because I think you know other words that refer to that same etymological root of *gymno* something like a gymnasium and so did you know that a gymnasium was a place you're supposed to run around naked? Well, you're not really supposed to anymore but of course the origin of the course gymnasium was ancient Greece where it was sort of the open air location, where people would go an exercise and back in the day you would do so naked and so its the origin of that name gymnasium but it also helps us understand why these organisms are known as Sicilians are also referred to the naked snakes.

Caudata/Anura

The next order are the *caudata* which are the salamander as as the name refers *caudal* means it has a tail, and *cauda* is Latin for tail and so these are the amphibians that have a tail at

the adult stage, and that's one of the characteristics and particularly the characteristic that may distinguish them in one way from the *anura* which are the frogs and the toads and again they have a very similar name. Does it look similar to you? *Caudata* and *anura* are very very close to one another in fact they're quite the opposite, they're antonyms of one another. So if *caudata* means has a tail then what does *anura* mean? As an antonym it would mean obviously must reflect that it doesn't have a tail, so what is the origin in that word of the etymological word for tail. Does anybody recognize it? *Uro*? Have we seen it elsewhere? Where are we seeing *uro* from before? (Class murmur) *Uropod*! Yes so, the appendices and the crustacea that are the tail also we have the urochordata which are organisms that have chordate traits where? Only in the tail of the juvenile, so *uro* means tail! But it's Greek! *Cauda* is Latin for tail, *uro* is Greek for tail. And so, it's the same term except this one is the opposite *an-* or *a-*something means absence of, absence of the tail, so the frogs and the toads are those amphibia that don't have a tail in the adult phase and that's what their name reflects. So, as I've said before the *anura* is the order of amphibia that is the most diverse with around 4000 species and so that's what we generally tend to think of when we think of amphibia because there are more frogs and toads than the other kinds.