Enhancing students’ agency in learning anatomy vocabulary with a formative intervention design

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Abstract

One of the major challenges for health science students is the rapid acquisition of a new vocabulary in anatomy comprising several hundred new words. Research has shown that vocabulary learning can be improved when students are directed to vocabulary strategies. This paper reported a study with a formative intervention design inspired by Vygotsky’s method of double stimulation. In this design, the students were put in a structured situation that invited them to identify the challenges in learning anatomy and then provided them with active guidance and a range of anatomy vocabulary learning strategies that scaffolded them to work out a solution to the challenge and develop their individualized anatomy learning resources. The data were collected from surveys, pre- and post-quiz results, and group discussion transcripts. The results revealed students perceived one of the main challenges in learning anatomy was learning, memorizing and remembering many new words. A key finding in our study was that the formative intervention enhanced students’ agency in creating resources for learning anatomy vocabulary. In addition, the development of their understanding showed a recursive form: from concrete experiences to abstract concepts and then to concrete new practices.

Notes on Contributors

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Introduction

Correct use of anatomical vocabulary by physicians, surgeons and allied health professionals is an essential skill, crucial for describing and defining problems within the body with clarity and precision. It is acknowledged that students who fail to master vocabulary have even more difficulty learning about more complex anatomical processes (Chapman et al., 2017).

One of the major challenges for health science students is the rapid acquisition of a new vocabulary of several hundred new words in anatomy, many of which are derived from classical Greek or Latin. It may
be an even more daunting task for students from language areas not derived from these languages to understand the lexical meanings, and pronunciation of new terms (Lucas et al., 1997). Students come into class perceiving that there is a lot of information to learn, and that the material is difficult, so there is an acknowledged need for effective approaches to address these perceptions (Sturges & Mauner, 2013).

Research has shown that vocabulary learning can be improved when students are directed to vocabulary strategies. Nosidlak (Nosidlak, 2013) presents five essential steps for vocabulary acquisition: encountering new words, having a clear visual and/or auditory understanding of the form of new words, leaning the meaning of new words and linking the form and meaning, and finally, correct use of the word.

There are many second language vocabulary acquisition strategies. Presentation of images and hearing the spoken word simultaneously through the use of multimedia allows learners to form meaningful connections (Mayer, 2022). Learner generated resources such as flash cards have long been used for new vocabulary recall drills (Mubarak & Smith, 2008). Creating and labelling technical drawings have been used to demonstrate comprehension of concepts and their associated vocabulary (Van Meter & Garner, 2005). What is clear from these studies is that repetition is an important component in solidifying word acquisition.

Much of the literature regarding language learning strategies relates to secondary language acquisition; there are few studies specifically related to anatomy vocabulary. However, there are many available strategies that can be adapted to the learning of anatomy (Fendos, 2021). One strategy that has potential is morphemic analysis which emphasizes the analysis of relationships between Greek and Latin root words and their meaning (Wilkinson, 2007). More traditional anatomy learning techniques include drawing, use of atlases or coloring-in books, allowing the learner to link form and meaning through the generation of a mental model of anatomical structures (Rosse, 1999). There is also a plethora of online games and quizzes. Regardless of this abundance, it is necessary to provide students with constant application as well as diversity of study techniques (Sturges & Mauner, 2013). More importantly, research revealed that agentive students were likely to have higher achievement in anatomy learning (Rutenberg et al., 2022).

This paper reports a study with a formative intervention inspired by Vygotsky’s method of double stimulation. In this design, the students were put in a structured situation which invited them to identify the challenges in learning anatomy and then provided them with active guidance/second stimulus (e.g. workshop) which scaffolded them to work out a solution to the problem (development of individualized resources). The double stimulation design has been found to be an effective intervention in enhancing students’ agency ie. taking responsibility for improving their knowledge (Clark, 2016; Sannino, 2015b; Yang, 2021). The first aim of this study was to introduce students to a curated selection of anatomy vocabulary learning strategies. The second aim was to enhance students’ agency in creating resources for learning anatomy vocabulary.

**Vocabulary learning strategies**
Vocabulary learning has been a key research area in second language learning since the 1980s (Nation, 2013). Within this area, there has been increased interest in effective strategies and methods of technical vocabulary teaching and learning (Liu & Lei, 2020; Nation, 2001). Technical vocabulary refers to words used in a specific subject for communicating subject-specific knowledge (Nation, 2001). The coverage of technical vocabulary in anatomy text was found to be 37.6% (Chung & Nation, 2003), which indicates that technical vocabulary is essential for learning subject-specific knowledge (Yüksel et al., 2022). Some second language learners have viewed technical vocabulary learning as the major challenge in learning subject knowledge (Evans & Morrison, 2011). Although incidental vocabulary learning takes place for many learners, for technical vocabulary, intentional learning is required including many decontextualized techniques (Yüksel et al., 2022). This study aims to enhance students’ learning of anatomy vocabulary using two innovative strategies.

The first innovation of this study is the synthesis of multiple vocabulary strategies in a vocabulary workshop which comprised a rich range of resources as well as stimuli for students’ learning (detailed below). To have effective vocabulary learning, students need to learn and use a variety of vocabulary learning strategies (Ali et al., 2022; Nation, 2013). Effective strategies included morphological instruction and drill practice, mnemonics strategies, technology and multimedia supported strategies, such as digital flash cards, videos, and online quizzes.

Many technical anatomy vocabularies are rooted in Latin and Greek (Pampush & Petto, 2011). Research found that teaching Latin roots words contributed to students’ academic vocabulary learning (Crosson et al., 2019). It is important to provide multiple encounters for learners to make the connections between the morphological constituents and their meanings (Crosson et al., 2019). The necessity of having multiple encounters and practice, using methods such as ‘look, cover, write, check’ was confirmed as a popular strategy used by Latin language learners (Warwicker, 2019). In addition, word memorization and retrieval are more effective when the multiple encounters combine audio, visual and phonological presentations (Goldstein, 2011).

Online technology has been applied to support and enrich vocabulary learning strategies. Researchers have incorporated audio and visual input into digital flash cards to support vocabulary learning (Li & Tong, 2019; Nakata, 2011). An online Latin learning module in Open University used digital flash cards with audio, visual images and English equivalents for Latin vocabulary (Lloyd & Robson, 2019). Multimedia technology can maximize learners’ visual, verbal and auditory processing channels in terms of both capacity and duration (Rahimi & Allahyari, 2019). The popular multimedia technologies used for vocabulary learning include digital flash cards, videos and online quizzes.

Digital flash cards have shown effectiveness in facilitating technical vocabulary learning in a pharmacy course in Turkey (Yüksel et al., 2022) and in medical terminology courses in Iran (Alizadeh et al., 2021). In addition, some online vocabulary learning and quiz software, such as Quizlet (Quizlet Inc, San Francisco, CA) and Memrise (Memrise Inc, London, UK) also created interactive vocabulary learning resources (Robson & Graham, 2018).
Videos can also promote vocabulary learning (Chen et al., 2022; Teng, 2022) because the combination of visual image and verbal information (e.g. words with pictures) can enhance meaning recall and recognition (Chen et al., 2022; Mayer & Fiore, 2014; Teng, 2022). One study used multimedia to assist university students’ learning of technical vocabulary in an electricity course in Rwanda, with the video clips featuring images, sound and text to facilitate learning and retention of technical vocabulary (Rusanganwa, 2013).

Mnemonic vocabulary strategies refer to the use of visual or acoustic cues to assist the remembering of new information (Kuder, 2017). The popular mnemonics strategies include breaking down a long vocabulary into more familiar or abbreviated segments for memorizing (Atkinson, 1975; Fasih et al., 2018) or use picture-word pairing strategies to help with memorizing or understanding vocabulary (Phillips, 2016). Mnemonic strategies have been shown to be effective in technical learning subject content vocabulary (Azmi et al., 2016; Fasih et al., 2018) and clinic technical vocabulary in a nursing program (Kaur, 2022).

A systematic literature review synthesized of 33 studies on English vocabulary learning showed that 71.88% of the studies used an independent-group pretest-posttest design and 18.75% used a single-group pretest-posttest design (Lei & Reynolds, 2022). The focus of the traditional pretest-posttest design is the result rather than the learner. There is a need to make learners the subject who have the potential to be agentic and autonomous learners. The second innovation of this study is the formative intervention design, which aims to boost learners’ agency in identifying the issues or conflict in their learning and adapt or create their own learning resources via engagement with the series of stimuli provided.

Formative intervention is a method within the Cultural Historical Activity Theory (CHAT) which is underpinned by the epistemological principle of double stimulation (Engeström et al., 2022; Morselli, 2021; Sannino, 2015a). Double stimulation has been re-modelled by Sannino (Sannino, 2015b) as a process of fostering agency and includes several key elements.

The first element is a conflict of motives which is activated by giving or showing a person a challenging problem, which is also called the first stimulus (Hopwood, 2022; Sannino, 2015b). Second, in order to overcome or break away from the conflict of motives, the person needs to form auxiliary motives and take actions to change the situation/circumstance (Sannino, 2015b). The second stimulus is provided to offer resources and/or concepts that the person can use for analyzing and solving the problem (Hopwood, 2022; Virkkunen & Ristimäki, 2012). Agency is formed when the subject manages the problematic situation by using the provided second stimulus as the instrument to solve the problem (Virkkunen & Ristimäki, 2012). In other words, the process of motive formation and decision making depends on the use of the second stimulus (Sannino, 2015b).

When double stimulation is applied in formative intervention, it extends beyond the study of the individual’s agency to the formation of collective agency during the interaction between the researcher and participants and between participants (Sannino, 2015b). In addition, during the formative intervention, the participants tend to create or devise new instruments to solve the problem or modify the
initial task, which shows their enhanced agency (Hopwood, 2022; Sannino, 2015b). This is also a process of “reframing or reconceptualizing the problem situation” (Sannino, 2015a).

The double stimulation model has been applied in school activities (Barma et al., 2015; Sannino et al., 2016), school leaders’ professional development programs (Nuttall et al., 2018), teacher professional learning (Morselli, 2021), pre-service teachers’ epistemic agency in creating (Yang, 2021) and use of technology (Yang, 2022). The findings revealed that the double stimulation design and collaborative discussions enhanced pre-service teachers’ epistemic agency in creating new ideas and teaching resources (Yang, 2021, 2022). In particular, the collective appropriation and creation of ideas was developed through the process of interpreting, questioning, evaluating and reflecting in the group discussion and reflection on the multiple second stimuli (Ritella & Hakkarainen, 2012; Yang, 2021).

At the same time, double stimulation has also been used to analyze agency outside of research intervention or experiments, such as parents struggling with care of tube-feeding children (Hopwood, 2022; Hopwood & Gottschalk, 2017), and the support for students’ leadership in schools (Grant, 2022). This process of engaging with double stimulation is non-linear and recursive involving multiple second stimuli (Hopwood, 2022; Morselli, 2021).

Double stimulation is also applied in studies using participant’s memory as the second stimulus or mediating artefact for their problem-solving (Martin, 2015) and concept formation (Hedges, 2012; Sannino, 2015b). In this study, the aim is to use double stimulation to support students’ learning and memory of anatomy vocabulary. A series of vocabulary learning strategies are used as the second stimulus to support students’ agency in creating their own learning strategies and resources. This study is innovative in two aspects: 1) the interdisciplinary nature applying second language learning into anatomy vocabulary learning in medical science; 2) the application of the double stimulation design in the discipline of medical science.

The benefit to students who have developed confidence in how to learn anatomy may impact performance in assessment tasks (Choi-Lundberg et al., 2017). This is likely to relate to student agency with measurements of general students’ self-efficacy (Zheng et al., 2021) or specific “anatomical self-efficacy” ie. confidence learning and applying anatomical knowledge (Burgooon et al., 2012) correlating with academic performance.

This study centers around three research questions:

1. What are students’ perceptions about the challenges of learning anatomy vocabulary?
2. What factors influence these perceptions? We hypothesize that students with experience of learning a second language or learning anatomy will be less apprehensive about learning anatomy than students with no prior language or anatomy learning.
3. How does the formative intervention enhance students’ agency in creating resources for learning anatomy vocabulary?
Methodology

Research context

This study was conducted in a School of Medical Sciences at an Australian university. Speech Science is a compulsory unit taught in the first year of the Speech Therapy allied health program, and the Hearing and Speech science major. Half of the unit relates to the anatomy of speech and swallowing (head and neck, respiration). The remainder of the unit comprises physics and respiratory physiology. Anatomy instruction is taught over 11 hours of lectures, six hours of applied anatomy tutorial classes and six hours of practical sessions using cadavers, over 13 weeks. Structure, Function and Disease A is a compulsory unit taught in the first year of the Diagnostic Radiography allied health program. Seventy per cent of the unit is anatomy covering musculoskeletal, cardiovascular and respiratory systems. The remainder of the unit comprises physiology. Anatomy is taught over 12 hours of lectures, 11 hours of tutorial classes and nine hours of practical sessions using cadavers, over 13 weeks. All anatomy practical and tutorial rooms are designed for small group learning (tables of 6–8 students). The Anatomy learning workshops were held in week 1 and 2 after the first introductory lectures and before any anatomy practical classes.

Participants

All first-year students enrolled in the Speech Science or Structure, Function and Disease A units of study (2022) were eligible for inclusion (n = 263) in the anatomy vocabulary teaching intervention. The median age of the cohort was 19 years (Table 1). Eighty percent (n = 212) were female, attending university full-time (99%, n = 260) and were commencing students (94%, n = 249). There were 22 international students, the majority from China. The workshop was part of the scheduled class but use of data for publication was voluntary with informed written consent, and students could opt out at any time.
Table 1
Student Demographics

<table>
<thead>
<tr>
<th></th>
<th>Speech Science</th>
<th>Structure, Function and Disease A</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>2022 enrolment</td>
<td>128</td>
<td>135</td>
<td>263</td>
</tr>
<tr>
<td>Median age</td>
<td>19</td>
<td>19</td>
<td>19</td>
</tr>
<tr>
<td>Number female (%)</td>
<td>119 (93.0%)</td>
<td>93 (68.9%)</td>
<td>80.6%</td>
</tr>
<tr>
<td>Number international (%)</td>
<td>4 (3.1%)</td>
<td>18 (13.3%)</td>
<td>8.4%a</td>
</tr>
<tr>
<td>Australia Place of birth (%)</td>
<td>97 (75.8%)</td>
<td>79 (58.6%)</td>
<td>66.9%</td>
</tr>
<tr>
<td>English home language (%)</td>
<td>43 (33.6%)</td>
<td>29 (21.5%)</td>
<td>27.4%</td>
</tr>
<tr>
<td>Number full-time (%)</td>
<td>126 (98.4%)</td>
<td>134 (99.3%)</td>
<td>98.9%</td>
</tr>
<tr>
<td>Number commencing (%)</td>
<td>116 (92.8%)</td>
<td>132 (97.8%)</td>
<td>94.3%</td>
</tr>
<tr>
<td>Admission from high school (%)</td>
<td>105 (82.0%)</td>
<td>96 (71.1%)</td>
<td>76.4%</td>
</tr>
</tbody>
</table>

a (one Australian, one European, 12 Chinese, 3 from Hong Kong and Vietnam, one each from Singapore and Korea)

Study design framework

The aim of this study was to apply double stimulation as a pedagogical design and analyze the formation of students’ agency in changing their learning strategies (Table 2). All students were invited to participate in the study via announcements in lectures and the Canvas learning management system (Instructure, Inc, Salt Lake City, UT) in week one of semester. The workshop was run before any lectures had commenced. Data was collected from multiple levels: quizzes and follow-up quizzes, surveys and group discussions.
Table 2
Design framework and data collection procedures

<table>
<thead>
<tr>
<th>Design framework components</th>
<th>Data collection procedures</th>
<th>Data type</th>
</tr>
</thead>
<tbody>
<tr>
<td>First stimulus</td>
<td>Pre-workshop survey and quiz</td>
<td>Survey and quiz results</td>
</tr>
<tr>
<td>Second stimulus</td>
<td>In-class vocabulary workshop, Post-workshop quiz and survey</td>
<td>Quiz and survey results</td>
</tr>
<tr>
<td>New practice</td>
<td>Post-workshop survey Post-workshop quizzes, and group discussion</td>
<td>Survey and quiz results Group discussion audio-recording and transcript</td>
</tr>
</tbody>
</table>

Data collection procedures

First stimulus: Pre-tutorial survey and quiz

Before the workshop, students were encouraged to complete an anonymous online Pre-workshop survey (Presurvey) to investigate student perceptions of the challenges in learning anatomy as well as basic background data on whether they had studied anatomy or another language previously. At the beginning of the workshop, students were asked to complete a short online multiple-choice quiz (PreQuiz) which assessed content that had not previously been covered and was unlikely to be part of the students’ knowledge base. Questions comprised a mix of 10 simple image-based questions. The purpose was to raise their awareness of the gap in their knowledge and form the conflict of motives for learning.

Second stimulus: In-class vocabulary workshop, post-quiz and survey

The workshop was designed to introduce students to a range of different anatomy vocabulary learning strategies. Students were randomly assigned to one of six different learning strategies. These were designed to include activities that were relatively passive (watch a video), moderately passive (flip cards, hotspots, drag-and-drop) or active (draw and label, look-cover-label-check).

Students were given 10 minutes to use one activity to learn a vocabulary list of 10 anatomical structures (Online Resource 1). In the workshop, it was expected that students would repeat each activity multiple times in the scheduled time. This was based on the understanding that in foreign language vocabulary acquisition, repetition strategies or practiced retrieving are critical (Duff, 2000; Larsen-Freeman, 2012). Within an anatomy context, repetition activities in the form of flash cards are an effective strategy for at least longer-term knowledge acquisition (Dobson et al., 2017; Morin et al., 2019; Schmidmaier et al., 2011; Zheng et al., 2021). The more active repetition strategies have been less studied, but drawing has been demonstrated to be an effective strategy in anatomy (Backhouse et al., 2017; Mathon et al., 2021; Ritchie...
et al., 2022) and histology (Balemans et al., 2016), with some evidence for improved long-term retention (Balemans et al., 2016). Dynamic labelling of anatomical landmarks has also proved to be interesting for students (Khalil et al., 2005; O’Byrne et al., 2008) and effective (Hallgren et al., 2002).

After 10 minutes practice, a post-quiz (PostQuizDay1) and survey (PostSurvey1) was run. The quiz (PostQuizDay1) comprised of a mix of 10 simple image-based questions assessing the same content as the pre-workshop quiz. In the survey (PostSurvey1) students evaluated the perceived benefit of the assigned learning strategy as ‘useful’, ‘liked’, ‘will use’ or ‘fun’, each with a four-point Likert response scale (strongly agree, SA; agree, A; disagree, D; strongly disagree, SD).

In the next 30 minutes of the workshop, students were encouraged to try as many of the different strategies as they wished.

New practice: post-workshop survey, quizzes and group discussions

After the workshop, the students took a second survey (PostSurvey2) to identify their preferred learning strategy and nominate which strategy they would use in future study. At the end of the workshop, students were presented with the results of the quizzes and surveys and were led in a whole-group discussion of the results. Post-workshop quizzes were re-run the following day (PostQuizDay2), the following week (PostQuizWeek2) and four weeks later (PostQuizWeek5). All quiz questions were drawn from the same pool of questions. These quizzes also incorporated questions on their planned learning strategies.

After the workshop, students who had volunteered, participated in a 10–15-minute scaffolded discussion session. The open-ended discussion questions were provided on a worksheet and encouraged students to retrieve prior knowledge, reflecting on the issue, expressing opinions, questioning and reasoning (Muhonen et al., 2017). This can help with problem-solving and conceptual understanding (Mercer, 2008) and integrate students’ reflection with dialogical interaction (Sorenson & Brooks, 2018) (Online Resource 1). Discussions were conducted over Zoom and both the audio-recorded discussion and completed worksheets were collected as data. Participants were also asked to volunteer their developed resources for analysis. However, no students submitted any material.

**Data analysis**

In this study, students’ prior language learning and language background were identified and grouped into East Asian (China, Japan, Korea), South Asian (India, Pakistan, Bangladesh, Sri Lanka), South-East Asian (Vietnam, Cambodia), Middle Eastern (Arabic) and European. Statistical analyses were carried out using SPSS statistical package for Windows, version 26.0 (IBM Corp., Armonk, NY). Discrete variables were presented as frequency (n) and/or percent (%).

1. Surveys A descriptive analysis was undertaken of survey results followed up by a chi-square test of independence comparing language groups and prior anatomy knowledge and anticipated challenges
expected in learning anatomy. Open-ended responses to perceived challenges were thematically analyzed for patterns. The strength of association between these perceived challenges (open- and closed- responses) was estimated using Cramer’s V. Strength is reported as moderate if in the range 0.1–0.5 (Cohen, 1988).

2. Quiz data A two-way mixed ANOVA was performed to assess the effects of workshop and timing on quiz score: PreQuiz, after first workstation (PostQuizDay1), 2 days (PostQuizDay2), 2 weeks (PostQuizWeek2) or 5 weeks (PostQuizWeek5) post-workshop. Homogeneity of variance was tested by Levene’s test. Significant interactions were followed by pairwise comparisons using a Bonferroni test for post hoc analyses. All results from these analyses are presented as mean ± standard deviation (SD). Results were considered statistically significant at \( p < 0.05 \).

3. Discussion data

From a Cultural Historical Activity Theory (CHAT) point of view, the evidence of participants’ agency formed during the formative intervention is evidenced by the qualitative changes in participants’ understanding and reconceptualization of the object of their learning activity (Sannino et al., 2016). The group discussion guide and worksheet were designed based on the structure of double stimulation (Yang, 2021, 2022). The group discussion and the worksheets could ‘crystallize’ their cognitive process (Hennessy et al., 2016; Ritella & Hakkarainen, 2012). The analysis of the qualitative data, including the discussion transcripts and worksheets focused on the shift of participant students’ understanding about and reconceptualization of anatomy vocabulary learning strategies.

The transcription of the group discussions and worksheets were entered into NVivo (NVivo 1.5.1 (940), QSR International, LLC) for a concept-driven thematic coding and analysis. There were three rounds of analysis. Nodes and themes that emerged from the qualitative data analysis are listed in Table 3. The initial round focused on the coding of the anatomy vocabulary learning strategies that the participant used before the vocabulary workshop, those that they learned from the workshop and those that they would like to continue, as well as the vocabulary learning resources they would like to create for their future learning. The second round of analysis included the coding and analysis of the transcripts of students’ discussion based on the Scheme for Educational Dialogue Analysis (SEDA) with eight clusters of coding schemes (Online Resource 2) (Hennessy et al, 2016).

Based on the first two rounds of analysis, the third round of analysis focused on the cross-stage comparative analysis and the emergence of any conflict of motives and the participant students’ agency in engaging with and adapting the second stimulus for their own learning needs (the engagement with the 2nd stimuli), and their agency in the new practice, which were identified as the key principles of double stimulation design (Sannino, 2015b). The analysis identified the evidence of the participants’ new understanding and intention to create resources for their own anatomy vocabulary learning.
<table>
<thead>
<tr>
<th>Initial coding: Vocabulary learning strategies</th>
<th>The 2nd round of coding: SEDA</th>
<th>The 3rd round of coding: Concept-drive categorisation and subthemes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Before the workshop</strong></td>
<td></td>
<td><strong>Conflict of motives</strong></td>
</tr>
<tr>
<td>Prefixes/suffixes</td>
<td>B: Build on ideas (n = 10)</td>
<td><strong>Subthemes</strong></td>
</tr>
<tr>
<td>Drawing</td>
<td>C: Connect (n = 5)</td>
<td>1. Challenges</td>
</tr>
<tr>
<td>Diagrams and videos</td>
<td>R: Make reasoning explicit (n = 5)</td>
<td>2. Reflection on prior use of strategies</td>
</tr>
<tr>
<td>Flashcards</td>
<td>P: Positioning and coordination of ideas (n = 3)</td>
<td>3. Gaps in the knowledge</td>
</tr>
<tr>
<td></td>
<td>R: Reflect on dialogue or activity (n = 2)</td>
<td>4. Need for more learning</td>
</tr>
<tr>
<td></td>
<td>E: Express or invite ideas (n = 1)</td>
<td></td>
</tr>
<tr>
<td><strong>From the workshop</strong></td>
<td></td>
<td><strong>Engagement with the 2nd stimuli (workshop attendance)</strong></td>
</tr>
<tr>
<td>Drawing</td>
<td>P: Positioning and coordination of ideas (n = 7)</td>
<td><strong>Subthemes</strong></td>
</tr>
<tr>
<td>Labelling</td>
<td>B: Build on ideas (n = 6)</td>
<td>1. The need for multiple strategies</td>
</tr>
<tr>
<td>Hot spot</td>
<td>C: Connect (n = 2)</td>
<td>2. Connect personal experience with concepts</td>
</tr>
<tr>
<td>Drag and drop</td>
<td>G: Guide direction of dialogue (n = 1)</td>
<td></td>
</tr>
<tr>
<td><strong>For future learning</strong></td>
<td></td>
<td><strong>New practice</strong></td>
</tr>
<tr>
<td>Flow charts</td>
<td>P: Positioning and coordination of ideas (n = 9)</td>
<td><strong>Subthemes</strong></td>
</tr>
<tr>
<td>Regular quizzes</td>
<td>B: Build on ideas (n = 8)</td>
<td>1. Synthesise strategies from the workshop</td>
</tr>
<tr>
<td>Drawing</td>
<td>E: Express or invite ideas (n = 2)</td>
<td>2. Integrate anatomy vocabulary with the structure</td>
</tr>
<tr>
<td>Written notes</td>
<td>R: Make reasoning explicit (n = 2)</td>
<td>3. Categorise vocabulary</td>
</tr>
<tr>
<td>Categorizing information</td>
<td>E: Express or invite ideas (n = 1)</td>
<td>4. Self-created resources</td>
</tr>
<tr>
<td>Toggle notes (i.e. active recall, spaced repetition)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Colour coding</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drawing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scrapbook</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apps for learning</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teaching /explaining the concept to someone</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Results

What are students’ perceptions about the challenges of learning anatomy vocabulary?

The pre-workshop survey was designed to investigate student perceptions of the challenges in learning anatomy as well as basic background data on whether the students have studied anatomy or another language previously. The enrolled cohort was 263, of which 133 began the survey, 14 did not consent to use of their data and 35 did not complete any of the survey questions and were excluded.

Of the remaining students, 72.6% had previously learnt a foreign language, largely as a home language (65.5%). Languages learnt were 36% East Asian (Mandarin Chinese, Japanese), 22% Middle Eastern (Arabic, Turkish), 19% European (Latin, French, German, Spanish, Greek, Italian), 14% South-East Asian (Burmese, Korean, Tagalog, Indonesian, Vietnamese) and 9% South Asian (Tamil, Gujarati, Urdu, Bengali). Most students had no experience in learning anatomy previously (71.4%). Those who had some experience learnt this at high school (66.7%).

Open-ended responses to questions asking students to reflect on challenges in learning anatomy were analyzed and grouped into themes (Fig. 1). The dominant themes were: “memorizing all the names of every structure” (28%), “remembering all the names” (24%), “learning new words, and concepts” (21%) and “the vast amount of new terms and vocab” (12%).

There was no significant association between students with prior experience in learning anatomy, students with different language backgrounds or level of second language competence and perceived challenges.

There was a significant association between where students learnt a second language and perceived challenges in learning anatomy, $\chi^2(15) = 28.481, p = .019$. The dominant concern for students whose second language was acquired at home was learning new terminology. Students who learnt a second language at high school were more concerned with remembering new words.

Students were asked to rank four close-ended questions relating to learning anatomy from least to most challenging (Fig. 2). More students (29%) thought learning a large number of new words would be the most challenging aspect of learning anatomy and learning to spell new words the least challenging (16%).

There was no statistically significant association between students with different language backgrounds and/or experience and anticipated challenge presented by learning a large number of new words ($\chi^2(10) = 9.048, p = .528$, spelling new words ($\chi^2(10) = 11.141, p = .347$) or learning Latin words ($\chi^2(10) = 8.550, p = .585$). However, there was a statistically significant association with learning new words ($\chi^2(10) = 23.468, p = .009$, moderate Cramer’s V = .390 between students with different language backgrounds, with European language learners more concerned than other language groups.
Most students thought learning anatomy would be stressful (74.7%). The conflict of motives was not evident in the survey results but emerged in the group discussion which is presented in the following section.

There was no statistically significant association between where students learnt a second language or level of second language competence and anticipated challenge presented by any of these challenges. There was no statistically significant association between students with prior anatomy backgrounds and/or experience and challenges expected in learning new words or learning Latin words.

There was a statistically significant association between students with prior anatomy backgrounds and/or experience and learning a large number of words ($\chi^2(2) = 8.156, p = .017$, moderate Cramer's $V = .313$) and spelling new words ($\chi^2(2) = 8.497, p = .0014$, moderate Cramer's $V = .343$). Students with prior anatomy experience were least daunted by spelling new words and the number of new words (Fig. 3).

Content knowledge quizzes were run before and immediately after the first workstation, then repeated the following day, the following week and 5 weeks later (Fig. 4).

There was no statistically significant interaction between the workstation and quiz marks, $F(24, 220) = 1.355, p = .3131$, partial $\eta^2 = .129$. The main effect of quiz showed a statistically significant difference in mean mark at the different time points, $F(4, 248) = 116.203, p < .0005$, partial $\eta^2 = .652$. Pairwise comparisons of mean mark scores revealed pre-workshop mark was statistically significantly lower than mean quiz marks at all other time points. No other quiz marks were significantly different from each other.

**Workshop evaluation surveys**

After attempting all workstations, students were asked to rate the different methods of learning using a Likert scale (Fig. 5).

There was a statistically significant association between rating of workstation for “fun” ($\chi^2(15) = 25.879, p = .039$) and “will use” ($\chi^2(15) = 29.941, p = .012$). More students strongly agreed (SA) or agreed (A) that they would use flip cards and labelling.

There was not a statistically significant association between rating of workstation and perceived usefulness ($\chi^2(10) = 7.894, p = .639$) and liked, ($\chi^2(15) = 16.363, p = .358$).

**How does the formative intervention enhance students’ agency in creating resources for learning anatomy vocabulary?**

Five groups of students volunteered to participate in discussion groups. Two groups refused permission to use their data for analysis, one group did not actively engage with the discussion points. There were nine students (in two groups) who gave consent to participate in the group discussion held in the two weeks following the workshop. Excerpts 1–6 of the discussions are provided in Online Resource 2.
Discussion transcripts were analysed using the three themes identified in Table 3 and the excerpts were included in Online Resource 2.

**Conflict of motives**

As shown in the initial survey results, students identified a challenge of learning anatomy was memorizing a large number of new words in connection with structure and concepts. The conflict of motives emerged and shifted to auxiliary motives in their discussion, as shown in Excerpt 1 of Group 1’s discussion.

When students were reflecting on their strategies for learning anatomy before participating in the workshop, their awareness of the need to have multiple learning strategies emerged (Excerpt 1 Turns 4–7). In addition, students made connections between their everyday experience to some concepts in learning. For instance, in Turn 1, S3 reflected on their strategies of learning anatomy using flash cards and rote learning but indicated that that was not suitable for learning anatomy. After S2 pointed out that rote learning was rather an individual study, S3 built on this by proposing to have some fun learning by watching videos (Turn 3). Interestingly, in Turn 4, the student posed a question and said that they did not use any specific strategy. This indicated the gaps in their knowledge that they were not aware of any strategies used for learning anatomy. However, when they reflected on and connected to their background of Greek, they started building the relevance of using prefixes and suffixes in learning anatomy vocabulary. In Turn 5, S2 confirmed S3’s connection with etymology and further connected with their experience of drawing diagrams when learning biology in their high school (HSC) study. In Turn 6, S3 was inspired and connected to their experience of drawing and use of an anatomy atlas. Via the explanation and evaluation of the functions of that application, they further connected anatomy vocabulary to the understanding of the structure, “layers, like from bones to muscles”. Then in Turn 7, S2 connected their reflection on various learning strategies and resources to the conclusion that they needed to use multiple resources and related to visual learning introduced in the workshop. This was a sign that they formed the auxiliary motive for learning anatomy, which was to use multiple resources. Then S2 further confirmed that visual learning helped their anatomy learning, which could be viewed as a more specific object for learning. Following that, in Turn 8, S3 proposed real-life application as an object for their learning.

The effectiveness of using the quiz to raise their awareness of conflict of motives was also evident in Group 2’s discussion. As shown in the quote below, the student confirmed that the use of the first stimuli raised their awareness about the need for further learning:

“...as soon as I started doing the quizzes and I couldn’t reference the answer, I had to actively try and figure this out on my own. And then later I looked at the answers, like, ‘oh, my God, I got one wrong’, it sticks in my mind so much more.” (S2 in Group 2)

Here the phrases “actively try” and “figure this out on my own” showed the student’s agency in active learning. This also confirmed that the use of a quiz as the first stimulus enhanced their learning like “it sticks in my mind”.

Engagement with 2nd stimuli

In Excerpt 2, when Group 1 discussed why they need strategies for learning anatomy, S2 put an evaluative position that rote learning was not adequate (Turn 1). After getting confirmation, S2 further recalled how a song about anatomy enhanced their memory of the vocabulary (Turn 3). After that, S1 synthesized their ideas that it is good to have multiple ways of learning (Turn 4). S3 added that multiple strategies make the learning process more fun (Turn 5) and S1 added that it enhanced remembering (Turn 6). This showed the development of their understanding of the importance of having multiple vocabulary learning strategies with reasoning.

Group 2’s discussion also demonstrated that their understanding of learning anatomy moved from personal experiences to concepts and was expanded. As shown in Excerpt 3, in Turn 1, S3 expressed dislike towards using palm cards for learning anatomy though they also acknowledged their effectiveness. In Turn 2, S2 further confirmed the effectiveness of using palm cards. After that, they connected the rote learning of using palm cards to the concept of morphemes which indicated the connection between everyday practice and a metalinguistic concept. In addition, they added another strategy of drawing and confirmed the effectiveness by referring to their increased confidence. In Turn 3, S4 synthesized S2 and S3’s ideas and concluded that it is necessary to have multiple strategies. In Turns 5–6, S1 and 2 not only agreed with the idea of using multiple strategies for learning anatomy, but also further justified this idea from the affective aspect of “more fun” and a progressive learning habit, like “into a routine” (Turn 7). This showed how the dialogue enhanced and expanded their understanding of these strategies with knowledge of ‘how’ and ‘why’.

New practices

In PostSurvey2, students were asked to describe their planned study approaches. Most students planned to develop their own resources (35, 53.0%) or use pre-existing resources such as flip cards (30, 45.5%). Only one student (1.5%) decided against using any of the introduced methods of learning. Students who indicated they would develop their own resources were asked to describe which learning resources they planned to develop. Most students chose several strategies with flip cards (52, 82.5%), drawing (34, 54.0%), and look-cover-label (31, 49.2%) the most popular choices, followed by drag-and-drop (8, 12.7%) and hotspots (6, 9.5%). Some students (14, 22.2%) planned on using a different strategy. As for those participated in the group discussion, as shown in Table 3, their new practice would build on, synthesise and extend the strategies they used before the workshop and those that they learned from the workshop. In addition, they wanted to create their own resources for learning anatomy vocabulary. The group discussion elucidated the details of how their intentions and plans for new practice were developed during the discussion.

In Excerpt 4, when Group 1 discussed the strategies they would like to use in their future study of anatomy, S3 chose drawing as the strategy they wanted to further use and proposed an alternative way of annotating a print diagram (Turn 1). S2 used the activity name from the workshop to confirm S1’s idea of “drawing and labelling” (Turn 2). S2 further explained the importance of visualization, hearing and
structure for learning anatomy by comparing the difference between looking at a diagram of anatomy and a real person in their future work context (Turn 3). S2’s input showed their awareness of the importance of having multiple strategies and resources for learning. Based on that S1 proposed the use of flowcharts to connect the types of information mentioned by S2 (Turn 4). In Turn 5, S3 confirmed S1’s idea and further added that flowcharts would be easier than only writing. This showed their agency in synthesizing the strategies and resources from the workshop and their intention to create something suitable for their own learning needs. In addition, compared with Except 1, their understanding of anatomy learning has been changed from the lack of awareness of strategies, or using single strategies, to a more comprehensive understanding of multimodality and multiple strategies in learning, evidenced by S1’s words “everything is connected”. In addition, they connected their learning to the need of synthesizing all the information in a real-life working context (Turn 3).

Similarly, the students in Group 2 also developed a more integrated understanding of learning anatomy vocabulary by synthesising the strategies from the workshop (Excerpts 5 & 6). In Turn 1, S3 planned to use drawing and annotating as their strategy. S2 further confirmed that drawing was a good way of learning. In addition, they drew an analogy between anatomy learning with language learning. To them, it is more important to be able to use language for communication, such as “tell me about your day”, than only comprehending a sentence passively. Similarly, they believed that effective anatomy learning meant constructing and connecting the individual words with the structure “put the pieces in yourself”, which refers to deep learning “deep in my mind” (Turn 2). This indicated that their object of learning moved from memorization to a more comprehensive and integrative understanding of anatomy vocabulary in relation to other knowledge. Regarding the identified challenges in the initial survey that was to memorize new words in relation to structure, this was the evidence of their intention in engaging in new practice and resolution to the perceived challenge. This was confirmed by S3, evidenced by a series of verbs “draw... labelling and mind mapping” which showed a higher order thinking of categorizing the vocabulary. In Turn 4, S2 further connected the discussion to the functions of anatomy as it “makes sense for where it is”. In Turn 5–7, S4 and S2 summarized the strategic use of vocabulary learning strategies, which is a sign of their knowledge of ‘why’. In Turn 8, S2 not only emphasized the affective aspect of having multiple strategies to be “less boring”, but also lifted up to “more pathways in your brain”. This except showed that their knowledge of anatomy vocabulary learning was expanded and moved up to conceptual and structural levels via the engagement of the resources and collective discussion.

As shown in Excerpt 6, students in Group 2 created some new practices for their own learning, such as colour coding (Turn 2), drawing (Turn 3), scrapbook (Turn 4) and searched for apps for learning anatomy (Turn 5). In particular, when S2 provided an explanation for how effective drawing as a strategy will be, they related spatial awareness in addition to memorization. These were the evidence of their agency in creating and seeking resources for their learning, which emerged and were inspired by each other in the discussion.

Discussion
What are students’ perceptions about the challenges of learning anatomy vocabulary?

In the open-ended questions in our study, students perceived the greatest challenge in learning anatomy vocabulary related to the perceived volume of new words to learn, then the challenge of memorizing and “remembering all the names”. This was re-iterated in closed-ended responses where students thought learning a large number of new words would be the most challenging aspect of learning anatomy. This implied that the survey as the first stimulus raised students’ awareness of the perceived challenges in learning anatomy.

A recent survey of medical students came to similar conclusions with head and neck anatomy perceived as the most challenging topic and information overload being one of the most challenging aspects of learning (Cheung et al., 2021). Other studies of medical students have similarly revealed that students find the study of anatomy daunting (Choi-Lundberg et al., 2017; Smith & Mathias, 2010). First year medical students also strongly agreed that is difficult because it is memorization-based (Choi-Lundberg et al., 2017). In addition to content overload, a survey of first year allied health students noted difficulty with the technical language used (Sturges & Mauner, 2013; Yüksel et al., 2022). This difficulty transcended gender and ethnicity. This finding was also in line with other research’s findings from semi-structured interviews of second-year medical students that one of the challenges in anatomy was learning and remembering the many new names of structures (Wilhelmsson et al., 2010).

What factors influence these perceptions.

Our initial hypothesis supposed that students with experience of learning a second language would have the skills to learn the new vocabulary associated with learning anatomy and would be less apprehensive than students with no prior language learning. This was not proven. Students with a European language as a second language learners were more concerned about learning new words than other language groups or speakers without second language learning experience.

No student listed English as their second language. There is abundant literature discussing the difficulties faced by non-English speaking students to learning anatomy in English. This relates to the growing development of medical programs which encourage English as the instructional language. For example, English language proficiency is positively correlated with performance in anatomy and physiology among medical students taught in English as their second language (Ahmed et al., 1988; Hassan et al., 1995; Heming & Nandagopal, 2012; Jang, 2017; Tong & Shi, 2012). A significant proportion of the anatomical vocabulary derives indirectly from Latin or Greek. English also contains many words that derive indirectly from Latin or Greek. There is a general presumption that knowledge of Latin or Greek may assist student learning of anatomy vocabulary (Brahler & Walker, 2008; Pampush & Petto, 2011; Smith et al., 2007). The assumption is that fluent English speakers can draw on their existing vocabulary to assist in interpreting new words. The corollary is that speakers of non-Anglo European languages eg Asian or Arabic speakers, do not have the same existing etymological knowledge from which to draw. This also assumes that fluent English speakers have the capacity to analyze relationships between root words and affixes. This
confirmed that teaching students a Latin root word via multiple encounters was important for enhancing vocabulary learning (Crosson et al., 2019).

There are very few studies in the literature that relate to second or additional language background influences. First year medical students with a prior knowledge of Greek or Latin performed better in anatomy examinations than students with a second language or no other language (Pampush & Petto, 2011; Stephens & Moxham, 2018).

By design, our study was conducted before students had begun their study of anatomy, so the survey reflects their perceived challenges. We hypothesized that students with second language skills, particularly European, would have been formally taught skills in parsing, suffixes etc. which could have translated to anatomy vocabulary learning. This supposition was not borne out. Similarly, students may not be aware that their intrinsic knowledge of English would be beneficial in learning new anatomical terms. This indicates the necessity to provide explicit instruction in vocabulary learning strategies to raise students’ awareness of using their first or second knowledge in anatomy vocabulary learning.

A key finding in our study was that students perceived one of the main challenges in learning anatomy is learning, memorizing and remembering many new words. This is a common finding (Miller et al., 2002; Norman et al., 2022; Pandey & Zimitat, 2007; Smith et al., 2007; Ward, 2011). If students perceive that the main challenge to learning anatomy is the memorizing and remembering of large numbers of new words they may respond, unless guided, by adopting surface learning strategies (Smith et al., 2007). Perhaps in response to this perceived load, ~10% of medical students were observed to take a surface approach to learning relying on memorization (Norman et al., 2022; Ward, 2011). But this is perhaps an un-nuanced stance. It has been argued that due to the requirement to acquire a new vocabulary, a ‘surface learning strategy’ in the early stages of learning anatomy may be necessary (Pandey & Zimitat, 2007). That is, a preliminary stage of rote learning may be necessary in order to take a later deep approach. The problem, however, is when this attitude persists at the expense of understanding (Miller et al., 2002). Surface learning approaches have been correlated negatively with examination success (Everaert et al., 2017; Feeley & Biggerstaff, 2015; Postareff et al., 2018).

**Does students’ participation in the online workshop impact on long-term vocabulary retention?**

There was no statistically significant interaction between the first workstation experienced and quiz marks. The mean PreQuiz mark was statistically significantly lower than mean quiz marks at all other time points. The maintenance of significantly higher quiz marks following the online workshop are in agreement with previous studies that have shown that consolidation of vocabulary learning using repetition strategies (Duff, 2000; Gu, 2019; Larsen-Freeman, 2012; Peters, 2014) is crucial for retaining new words. Whilst it is possible that this is related to the vocabulary-image associations afforded by the image-based quiz questions (Mayer & Fiore, 2014), it also possible that it is due to the formation of student agency in developing learning resources. This is further supported by the lack of any statistically significant interaction between the workstation and the quiz marks suggesting that the lower quiz results of the PreQuiz acted as a trigger to form students’ agency regardless of the learning strategy employed.
Workshop evaluation surveys

After attempting all workstations, students were asked to rate the different methods of learning using a Likert scale. Interestingly, but perhaps not surprisingly, students strongly agreed (SA) or agreed (A) they would use workstation strategies, such as flip cards, that they found to be fun. Repetitive retrieval strategies such as flip cards been proven as an effective strategy for longer-term knowledge acquisition (Dobson et al., 2017; Morin et al., 2019; Schmidmaier et al., 2011; Zheng et al., 2021). Students’ preference for this learning strategy may also relate to prior experience with and/or the ease of access to readily available online resources for developing flip cards, such as Quizlet (https://quizlet.com/), Anki cards and AnkiApp (https://apps.ankiweb.net/). Drawing has also been demonstrated to be an effective strategy in learning anatomy (Backhouse et al., 2017; Mathon et al., 2021; Ritchie et al., 2022) but although the majority of students found drawing fun, they were more likely to nominate to use labelling strategies.

Firstly, both having fun and experiencing enjoyment were perceived by both learners and teachers as a motivator to attend classes and learn the knowledge and skills. This was evidenced in the group discussion: “Multiple ways of learning... making it more fun. Just that it's easier to remember” (Excerpt 2 Turns 3–6); “It is a lot more fun if you’ve got a process” (Excerpt 3 Turns 5–6). Secondly, fun and enjoyment were considered a mechanism that encouraged concentration by learners and helped in the absorption of learning. Finally having fun and experiencing enjoyment were identified as a proven way to build a socially connected learning environment. The research indicates that a greater focus on the affective domain of adults learning experience, in particular fun and enjoyment could prove to be as beneficial and important as it is currently considered in children's learning (Lucardie, 2014).

This study found no statistically significant association between rating of workstation and perceived usefulness. Pratama observed that for many younger adults, born in the late 1990s to early 2000s, as in this study, the perceived enjoyment (fun) of a learning strategy is more important to them than perceived usefulness (Pratama, 2020).

How did the formative intervention enhance students’ agency in creating resources for learning anatomy vocabulary?

The findings revealed insights into students’ agency formed during the formative intervention. First, students’ agency emerged from their awareness of their learning needs, to forming their auxiliary motives via engaging with the second stimulus and was further demonstrated in their enhanced intention to create learning resources. Second, the development of their understanding exhibited a recursive pattern: from concrete experiences to abstract concepts and then to concrete new practices. Third, the findings revealed a dialectical relationship between the expanded understanding of anatomy learning and their agentic actions.

The findings were in line with the claim that formative intervention can foster participants’ transformative agency (Hopwood, 2022; Sannino, 2015b). The emergency of their agency started from the conflict of
motives, which was the gap between their awareness of their needs and their actual lack of strategies for their anatomy learning. In this study, the use of the survey and the pre-workshop quiz as the first stimuli activated the participants’ conflict of motives. The survey results showed that the key challenges in their anatomy learning were the memorization and retention of anatomy vocabulary, which confirmed that the first stimuli presented a challenging problem acknowledged by the participants (Hopwood, 2022).

The initial conflict of motives shifted during students’ engagement with the series of second stimuli including their participation in the vocabulary strategies workshop, the post-workshop quizzes, and the group discussions. As shown in the group discussions (Excerpt 1 Turn 4–7; Excerpt 2, Turn 4), their awareness of using multiple strategies for learning anatomy increased. This indicated the formation of their agency when they used the artefacts, including multiple strategies and resources introduced in the workshop, to cope with the issue activated in the issue (Sannino, 2015b). This finding not only confirmed the claim that students need to learn and use a variety of vocabulary learning strategies for an effective vocabulary learning (Ali et al., 2022; Gu, 2019; Nation, 2013) but also highlighted the importance of raising their awareness of their learning needs. In addition, students gradually formed their own object for learning, such as visual learning or the need to connect anatomy vocabulary with real-life applications. This finding was in line with the claim that visual images can enhance vocabulary meaning, recall and recognition (Li & Tong, 2019; Mayer & Fiore, 2014; Nakata, 2011; Teng, 2022). This also confirmed that the second stimuli, including the workshop and group discussions, supported their motive formation and the process of decision-making (Sannino, 2015b).

During the group discussion, students exchanged and contributed ideas, via reasoning, evaluation and reflection. The development of their understanding was demonstrated in two aspects: 1) expanded understanding, and 2) connection between everyday experience and concepts. For instance, in Excerpts 2 and 3, their understanding of using multiple strategies was expanded covering affective (having fun), cognitive (memorization), and behavioral aspects (routine). At the same time, they were able to connect the everyday practice of anatomy learning with some metalinguistic concepts, such as morphemes. This finding confirmed that the double stimulation design can enable the interaction between every day and scientific concepts in development (Vygotsky & Cole, 1978). In addition, when double stimulation was applied in a formative intervention, the group discussion expanded their individual agency to the formation of collective agency (Sannino, 2015b).

Students’ understanding was further expanded in the discussion relating to the new practice they intend to engage. For example, in Excerpt 5, the student argued that effective anatomy learning should connect the individual vocabulary with the structure of the human body. This indicated the shift from rote learning and memorization as the object to more deep and comprehensive learning with spatial and structural awareness (Excerpts 5&6). In line with that, the student came up with some ideas about creating their own learning resources, such as flowcharts and scrapbooks. This showed a move from the initial concrete (prior experiences) to the concept, and then to concrete (new resources). This finding confirmed that in formative intervention, the participants would progressively move away from the models presented in the second stimuli to new ones (Engeström, 2011; Hopwood, 2022). The ideas for new
practices and resources were the signs of their agency in creating new tools to resolve the problem or refine the initial task (Van der Veer & Valsiner, 1991). This finding echoed other research that after engaging with an online Latin learning module, some students created their own interactive vocabulary quiz (Lloyd & Robson, 2019). In this stage, the students broke away from the initial conflictual situation of lack of strategies for learning anatomy. In addition, they reconceptualized the situation via their expanded understanding of the need and methods of learning anatomy (Sannino, 2015a).

The findings also revealed the dialectical relationship: on the one hand, their agentic actions in initiating and contributing to the discussion expanded their understanding; on the other hand, their expanded understanding enabled their agentic actions (Hopwood, 2022). The findings of this study confirmed that double stimulation enhanced the participants’ memory and concept formation (Martin, 2015; Sannino, 2015b). Researchers highlighted the importance of encouraging students to be active agents in their learning (Rutenberg et al., 2022). This study demonstrated that formative intervention underpinned by double stimulation can effectively empower students’ agency in being active participants and creative in their learning.

Limitations

Although the workshop was run in-class, only the data from student volunteers was included in the study. Students were free to complete quizzes and surveys with variable and potentially biased interaction. Although most (89%) students volunteered to participate in the study, only 32% actually completed the first survey. Most students completed the pre-workshop quiz and first post-workshop quiz. However fewer participated the following day (97%), following week (43%) or four weeks later (28%). In these intervening periods, it is unknown if students studied (ie relearned) before each post-quiz. Repetitive testing has been demonstrated to be a superior learning strategy than repetitive studying for short-term knowledge retention (Schmidmaier et al., 2011).

Even fewer students (9 or 3.9% of the available student population) were motivated to attend discussion groups. These are likely to be the most highly motivated of students and as such there is a risk of volunteer bias. Another limitation was that although the discussion captured students’ plan in engaging in the new practice, this paper had no direct data of the artefacts of their new practice.

Conclusions and implications

Students perceived one of the main challenges in learning anatomy was learning, memorizing and remembering many new words. This perception was not significantly influenced by prior experience in learning anatomy or a second language. The use of a formative intervention enhanced students’ agency in creating resources for learning anatomy vocabulary, emerging from their awareness of the challenges in learning and needs to learn more about anatomy vocabulary learning strategies. Their agency was enhanced via their engagement with the anatomy vocabulary workshop acting as an effective second stimulus in developing student agency. Student understanding of their learning needs developed
recursively; from concrete encounters experienced in the workshop to abstract concepts and then to concrete new practices. Thus, students’ knowledge of anatomy vocabulary learning was expanded and moved from conceptual via the engagement with the workshop and collective discussion. Encouraging students to develop an understanding of their learning needs is a useful strategy to encourage the development of learner agency.

**Declarations**

**Ethics approval**

Ethics approval was granted by The University of Sydney Human Research Ethics Committee: Protocol number: 2021/957.

**Consent to participate**

Informed consent was obtained from all individual participants included in the study.

**Competing interests**

We have no conflicts of interest to report in this study.

**Funding**

Nil

**Authors’ contribution**

The study was conceived and designed by all authors. HY led recruitment. Workshops were led by HR and EH. HY and EH led post-workshop discussion groups. HY conducted the qualitative analysis; HR conducted the quantitative data analysis. HY and HR wrote the first draft of the manuscript and all team members provided input on subsequent drafts. All authors read and approved the final manuscript.

**References**


**Figures**
Figure 1

Influence of language background on perceived challenges in learning anatomy. Open-ended responses to reflections on challenges in learning anatomy (n=58) were grouped into themes “memorizing”, “remembering”, “learning new terminology” and “volume of material” by whether students had a second language acquired at home, high school, other or no second language.

Figure 2

Challenges in learning a new anatomy vocabulary. Likert scale responses to questions examining students’ perceived challenges to learning anatomy (n = 84). Students were asked to respond to the statements “Do you think you will find …” a, “learning a large number of words.” b, “spelling new words”; c, “learning new words” and d, “learning Latin words” using a three-point Likert scale (1 = least challenging; 2 = medium challenging and 3 = most challenging).
Figure 3

Influence of prior anatomy background on perceived challenges learning a new anatomy vocabulary. Likert scale responses regarding questions examining student perceived challenges to learning anatomy (n = 77). Students with prior anatomy background (PriorAnat) perceived learning large number of words (a) and spelling new words (b) least challenging compared to students with no prior anatomy background (NoAnat).

Figure 4

Quiz marks before and after workshop. Mean quiz marks (and standard errors) (a) before and after the first workstation. Students were randomly assigned to six different workstations: watch a video (n=89), flip cards (n=28), look-cover-label a diagram (n=36), hotspots (n=18), practice drawing (n=40) and drag-and-drop (n=25) (b) The quiz was retaken the following day (PostQuizDay2, n=176), following week (PostQuizWeek2, n=107) or five weeks later (PostQuizWeek5, n=70).
Figure 5

Student attitudes to different learning strategies Likert scale responses regarding questions examining student attitudes to specific learning strategies. Students (n = 229) were asked to respond to the statements a, “I think the method of learning will be useful” b, “I liked the method of learning”; c, “I will use this method of learning” and d, “I thought the method of learning was fun” using a four-point Likert scale (1 = strongly disagree; 2 = disagree; 3 = agree; and 4 = strongly agree).

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- OnlineResource1.docx
- OnlineResource2.docx