Impact of the “Drugspeak” Program on Drug Name Pronunciation Skills and Perceptions in a Pharmacy Student Cohort

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Abstract

Background: Medication errors can lead to life-threatening outcomes. Such errors can arise from the poor pronunciation of drug names, leading to the unintentional administration of incorrect medicines to patients. In our experience, students experience difficulties in pronouncing many drug names. We have devised a pilot study called DrugSpeak to provide students with the educational scaffolding required to pronounce both familiar and unfamiliar drug names correctly.

Methods: A total of 26 willing student participants from a second-year Pharmacy course were provided access to online videos and audio recordings of drug names, and undertook a workshop that provided them with basic phonetics training to assist them in pronouncing drug names correctly. Students conducted audio recordings of a list of drug names at the start and end of the course, as well as surveys both before and after the intervention with the DrugSpeak Program.

Results: Significant increases in student performances in terms of drug pronunciation and accuracy were observed following the DrugSpeak program. Students were strongly supportive of the DrugSpeak program in their coursework and perceived a high importance of drug pronunciation at university and in their future career paths. They also reported reductions in anxiety and improvements in their confidence levels arising from DrugSpeak in terms of their drug pronunciation proficiency levels.

Conclusions: The DrugSpeak Program yielded promising outcomes in the improvement of student drug pronunciation skills, and in providing students with confidence to tackle drug names unfamiliar to them. Future studies will address the extensibility and effectiveness of the program in other health degree courses.

Background

Medication errors lead to preventable medication-related adverse drug reactions, hospitalisations, and deaths, with an annual global cost of US$42 billion [1]. There are numerous contributing factors that lead to medication errors. Up to 25% of all errors arise when patents receive the incorrect drug when another drug was intended for treatment, also known as “wrong drug” errors [2, 3]. This is commonly associated with pairs of drug names which possess confusingly similar names both orthographically (written) and phonetically (spoken), and are known as look-alike, sound-alike (LASA) drugs [4–6]. Such medication errors present a serious threat to patient healthcare and can lead to malpractice claims against pharmacists and other healthcare professionals [7]. Exacerbating this problem are the difficulties experienced by both students and clinicians alike in recalling drug names [8–10], especially since many of the names are long and contain multiple syllables. While numerous attempts have been made to address the difficulties associated with incorrect spoken medication errors, they have been met with varied success and without a suitable remedy to adequately address the problem [11].

The mispronunciation of drugs in the healthcare profession, particularly involving LASA drugs, presents another important source of medication error [12]. Fluency in drug pronunciation is an essential graduate

attribute for health professional students, and yet methods that improve student drug pronunciation proficiencies has received little attention. It is concerning that such an integral form of communication has been largely overlooked as a source of such errors [13]. Correct, uniform drug pronunciations are not only important in the healthcare sector to prevent the appearance of a lack of professionalism [14], but it is an essential mechanism by which the human transcriber delivers information on complex medications [15]. Indeed, verbal communication remains one of the highest-ranking employability skills in the STEM (Science, Technology, Engineering and Mathematics) industry [16]. In our experience, additional need for intervention in this regard arose from our observations that many students were unable to correctly pronounce many of the hundreds of drug names at the conclusion of their program in their final year of study [17], which leads to reduced graduate outcomes and poorer performances in job interviews. For example, a report more than two decades ago showed that students entering tertiary education are poorly equipped with requisite literacy skills but were also graduating without language proficiency in these skillsets [18] and there is little evidence since to suggest this has been rectified.

To assist in drug pronunciations, the phonetic spelling of the drug name can assist, but this requires proficiency in translating the drug name into the correctly spoken words [14]. Although pharmaceutical companies have included drug pronunciation in their medication information sheets, most consumers are neither versed in using the International Phonetics Alphabet to construct accurate pronunciations. Further, online sources of drug pronunciations are sparse and often utilise computer-generated speech that is inconsistently pronounced between sources [19]. While pronunciation “training” has been utilised with some success in the past to improve English word pronunciations in foreign language classes [20, 21], similar approaches have not been made for the pronunciation of generic drug names. Indeed, research into word pronunciation itself has been largely overlooked; hence, the pedagogy in this area remains uninformed due to the lack of connection between research and practice [22]. To redress this gap, the present study sought to improve second-year pharmacy student drug pronunciation skills though a collaborative study involving pharmacists and speech pathologists through the design, implementation, and evaluation of a drug pronunciation proficiency program which we named “DrugSpeak”. This program ultimately seeks to mitigate the risks of medication errors that could occur when our graduates begin employment in the healthcare sector.

Methods

Aims

The present study had two aims. First, we wished to gain an understanding of student perceptions of the importance of drug pronunciation in their studies and career. Secondly, we wanted to investigate whether a targeted intervention with the DrugSpeak Program resulted in improvements in student’s ability to pronounce drug names more accurately and fluently.

Participants

Students enrolled in the Integrated Pharmacotherapeutics 1 (2009PHM) course within their Bachelor of Pharmacy program at Griffith University (Gold Coast, Australia). The course contained 52 students. Of these, 26 students participated in the study, and comprised 18 female and 8 male students. The average age of the cohort was 22 years old, while the age distribution was from 19 to 46 years of age. Greater than 85% of students reported English as their native language, with the remaining comprising of Korean, Hindi, Telugu, Cantonese, Vietnamese and Arabic. The 2009PHM course was chosen since it the first course in their degree program where knowledge of specific drugs is required and assessed. Students were informed of the DrugSpeak Program and its design and purpose, and that it was being used to help students establish a solid foundation in drug pronunciation proficiency.

Surveys

A survey was conducted prior to any exposure to the DrugSpeak program intervention and repeated immediately after the DrugSpeak workshops. Student perceptions about drug names, student pronunciation learning strategies and their perceived importance of fluent drug name pronunciation were collected through six questions in this first survey. Students indicated their response on a 5-point agreement Likert scale (1 = Strongly Disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; 5 = Strongly Agree). To ensure participant confidentiality, students created a 6-digit code for their own identification during the study. Participant codes for the pre-workshop survey were further deidentified with a randomly generated 4-digit code for subsequent analysis to ensure researchers did not have access to student names that were connected to the original 6-digit code until after data analysis. This de-identification approach was used for all student surveys and recordings in the study. Towards the end of the course (and thus at the end of the DrugSpeak Program intervention) a second survey was conducted consisting of the same questions as the first survey. Finally, a third survey was conducted which included eight questions related to the students' experiences of the DrugSpeak Program.

The DrugSpeak program

The DrugSpeak program was underpinned by literature on linguistics specific to word pronunciation, as well as new word learning, neurolinguistics, and adult learning approaches. As such, the program primarily employed a bottom-up, skills-based teaching approach, but also taught complementary top-down pattern recognition strategies. Specifically, the program focused on teaching basic structural concepts and rules of word pronunciation, building up from phonemes (sounds) to syllables to words. At the word level, syllable identification, stress placement, intonation, melodic contours (prosody or suprasegmentals), and stem recognition were addressed [22–24]. The DrugSpeak program was delivered in the following order:

Part 1. Pre-workshop: students were provided access to three pre-recorded videos (of approximately 10 minutes duration each) on their course website. These videos covered the basics of word pronunciation, as well as the key fundamentals of spoken language, and were supplied to students on the first day of the course.

Part 2. Workshops: face-to-face active learning workshop (3 hours) delivered during tutorial classes. These “training” workshops applied the concepts introduced in the videos during Part 1, providing further instruction and application of pronunciation skills and strategies. During these workshops, students participated in small group activities to discuss the structure, phonetics, and suprasegmentals relevant to drug names, followed by verbal practice of 49 different drug names that had been selected for the intervention. Students were also supplied with audio examples of each drug name (which were made available on the course website for the entire duration of the course), which allowed them to compare their pronunciation attempts with those spoken by an expert, and to further practice their own pronunciations. Students completed the verbal tasks in pairs within groups and completed a workshop booklet, and then supplied with extra drug names for private study and practice outside of class.

Part 3. Post-workshop: students continued to have access to recordings located on the learning management system. Drug name pronunciations were also reinforced in lectures and tutorials.

Audio recordings

Audio recordings of drug name pronunciations were collected from willing participants under the observation of research assistants. Recordings were conducted in small private rooms which prevented interruptions and with minimal background noise. Two separate recordings were conducted for the cohort. A pre-program prior to starting the DrugSpeak program intervention and named the *pre-recordings*, and a post-program recording was conducted in the final week of the course following completion of DrugSpeak activities, which was named the *post-recordings*.

Audio was captured using Olympus WS-852 Digital Voice Recorders. Students were asked to pronounce a series of 113 drug names the were displayed at the centre of the computer screen on a PowerPoint presentation. Drug names were displayed individually (one drug name per slide), and students were permitted to advance to the next slide when ready for the next drug name. An audible alert signalled the display of the next new drug name. This assisted with downstream data analysis where the times between the display of the word and the attempt(s) made by students to pronounce them could be measured.

The presentation began with five “control” drug names that included simple and well-recognised drug names such as “aspirin” and “paracetamol” to ensure the participant was comfortable and a familiar with the procedure. The following 49 drug names included those studied during the DrugSpeak Program activities, workshops, and online materials. The drug names ranged from two syllables to seven syllables in length. These were followed by an additional 49 drug names that were different to those used in the DrugSpeak intervention but contained word structures that were deliberately matched (i.e. by number of syllables, length, and stress patterns) to the drug names used in the intervention. Using matched treated and untreated drug name sets in the pre-recordings and post-recordings helped determine whether the intervention was word-specific or if there were generalisation effects to untreated words from the strategies taught during the DrugSpeak program. The matching of the Treatment and Untreated sets was carried out by a speech pathology academic and were derived from a list of common drug names

provided by pharmacy academics. Towards the end of the recordings, ten drugs that would be completely unfamiliar to students, such as drugs not yet released, were presented (i.e. the “New” drugs). These final drug names served as a further measure of the extent to which students could apply and generalise the pronunciation principles learned throughout the DrugSpeak Program to drug names that were highly likely to be unfamiliar to them.

The post-recordings were completed by students in Week 11, and these included the same drug names as in the pre-recordings in Week 1. Since there were approximately 11 weeks between these and the pre-recordings, this was considered this to be sufficient time between recordings to prevent student familiarity with the words that were shown in the first recording, which could confound the research. The complete timeline of the project is shown in Fig. 1.

Data analysis

The pre-survey and post-survey responses to each question were counted and collected into groups based on response type and displayed using Tableau Software [25]. All de-identified audio recordings were stored in one folder containing their 4-digit codes without any indication of being from the pre-recordings or the post-recordings. This helped eliminate bias by the researchers which could arise since student attempts in the post-recordings may be perceived as more proficient. Analysis was performed using Audio Audition (2020), using a background noise reduction to remove baseline static, with accuracy and fluency being the key measures. Accuracy of pronunciation was determined according to phonetic sounds, syllables and stress placement criteria and compared to the correct phonetic transcriptions according to the International Phonetic Alphabet [26]. Exceptions were made for two different commonly used pronunciations e.g. <ine> could be pronounced as the [ine] in “dine” or [een] in “green”. Pronunciation errors were recorded as phoneme errors (syllables pronounced incorrectly), and stress errors (when stress was placed on the incorrect syllable). Pronunciation fluency was measured through the time taken (speed) to pronounce the word and was measured from the alert tone where drug names were displayed until the offset point in the speech sound wave. The time between the alert tone, rather than at the onset of speech, was considered relevant as this represented the time taken for the speaker to process the word, and thus allowed for differences between simple or familiar drug names and those that were unfamiliar or more complex to be studied. As a further indicator of fluency, the number of student attempts to pronounce each drug name were also determined, even in cases where the full word was not pronounced.

Once all parameters had been collected and data analysed, all de-identified audio files were matched by accessing a master document that revealed which files were pre-recordings and post-recordings. These could be identified by revealing student’s personal 6-digital codes and the date of the recording. This allowed us to finally link pre-recordings and post-recordings that were conducted with the same student. There were 66 audio recordings obtained in the study, of which 34 were identified as pre-recordings and 32 as post-recordings. Matching of the student codes showed that 26 student participants conducted both the pre-recordings and the post-recording. This allowed judgements to be made on the

improvements, if any, in student drug pronunciation skills following the intervention with the DrugSpeak program. Students who did not participate in either of the recordings were excluded from further analysis.

Statistical analysis

All statistical analyses were performed on audio recordings using IBM SPSS Statistics (Version 25, IBM Corp, Armonk, NY). A total of 2808 lines of paired data were collected across the 26 participants. The accuracy of pre-post paired responses was analysed using the nonparametric McNemar chi-square test with post-hoc analyses employing Wilcoxon signed-rank tests. Despite non-normal distribution (i.e., positively skewing) across the response time data for speed, the large data set and the fact that ANOVA is robust in handling outliers [27] indicated parametric statistical analyses, including ANOVA and paired t-tests (2-tailed) for these data.

Two additional fine-grained statistical analyses were undertaken related to accuracy and speed. First, to account for the fact that words ranged in syllable length from 2-7 syllables which hypothetically could influence accuracy and fluency, syllable-level analyses were conducted for accuracy and response time. Specifically, only those words that were correct both pre- and post-intervention were included in these speed analyses (N = 1404) to ensure further consistency. Prior analyses based on visual inspection confirmed that statistically significantly slower response times occurred for incorrect responses. Second, to investigate generalisation and word learning effects from the 49 Treated drug name word set presented throughout the DrugSpeak Program to the Untreated matched set and the 10 New Name set, pre-post comparisons were undertaken across these three sets for accuracy. Passed or skipped attempts were recorded as incorrect; however, this presented as missing data for the time and number of attempts parameters. All missing data was replaced with the total means for the question in line with studies that have shown the substitution of missing data with totals means is more accurate than data pairwise deletion [28].

For comparisons in pre-post survey responses, due to the relatively small sample size and use of ordinal matched-pair data, pre-post program confidence and perceptual data were analysed using nonparametric statistics, specifically Wilcoxon signed-ranks tests.

Results

First survey (pre-survey)

All 26 participants completed a pre-program survey with six questions to establish their baseline perceptions and confidence in pronouncing drug names (Fig. 2). There was no missing data. Almost half (46%) of these students were confident in pronouncing drug names with the remainder disagreeing (26.9%) or neutral. This was reflected by student anxiety where 35% of student disagreed that drug pronunciation made them anxious, although 7 students agreed with that question and 10 of the 26 students were neutral. Most students were either neutral or agreed that they can pronounce drug names quickly. There were 3 questions that almost all students agreed with, and these pertained to the

importance of drug pronunciation, perceptions of student and health professional competency, and pronouncing drug names correctly during job interviews.

Second survey (post-survey)

Following the DrugSpeak learning activity, 26 students completed a post-survey which contained the same questions as the first survey. There were only 5 missing responses across all questions. The results are shown in Fig. 3. Students once again agreed that they are confident pronouncing drug names (69.2%) but half of the cohort reported feeling anxious when unable to pronounce drug names. Students overwhelmingly agreed to the remaining questions on their ability to quickly learn how to pronounce drug names (76.9%), importance for students to correctly pronounce drug names (96.1%), perceptions that correct drug pronunciation is linked to the competency of other students or practitioners (65.4%), and importance of correct drug name pronunciations during job interviews (92.3%).

Comparison of pre- and post-survey responses

The mean scores for each of the six questions asked in the pre- and post-surveys were subjected to a Wilcoxon signed-rank test, and the results shown in Table 1. Statistically significant increases in the post-survey were observed for question 1 (confidence in pronouncing drug names) (Z = -2.54, p = 0.011) and question 3 (confidence in learning how to pronounce drug names) (Z = -2.84, p = 0.005) following DrugSpeak. Significant differences were not found for the other questions.

Table 1
Comparison of pre-survey and post-surveys responses. Questions where significant increases in rank mean of the responses (out of 5 using the Likert scale) were observed in the post-survey are indicated in bold. SD = standard deviation; Z = Z-value for a 95% confidence interval; df = degrees of freedom.

Question	Pre-survey score (mean ± SD)	Post-survey score (mean ± SD)	Difference	Z	df	p (2-tailed)
1	**3.27 ± 0.83**	**3.77 ± 0.82**	**0.5 ± 0.86**	**-2.54**	**25**	**0.011**
2	3.12 ± 0.86	3.38 ± 1.02	0.27 ± 1.08	-1.442	25	0.149
3	**3.62 ± 0.75**	**4.04 ± 0.66**	**0.42 ± 0.64**	**-2.84**	**25**	**0.005**
4	4.73 ± 0.45	4.8 ± 0.4	0.07 ± 0.4	-0.849	25	0.396
5	4.15 ± 0.97	4.25 ± 0.86	0.1 ± 1.07	-0.297	25	0.766
6	4.69 ± 0.47	4.64 ± 0.56	+0.05 ± 0.53	-0.452	25	0.651

Third survey (student feedback on DrugSpeak experience)

An additional post-survey was conducted in order to collect general student feedback on the DrugSpeak learning activity. The results are shown in Fig. 4. Almost all (92.3%) participants agreed or strongly agreed

it was a valuable learning activity, with the majority of students agreeing that DrugSpeak improved their ability to pronounce drug names. Most of the participants agreed or strongly agreed the program improved their confidence in pronouncing drug names (84.6%), enhanced their knowledge of phonetics (76.9%), and reduced their anxiety when encountering new names for the first time (65.3%). The anxiety data was complemented by the observation that most of the cohort (73%) disagreed with the statement that DrugSpeak increased their anxiety relevant to the pronunciation of unfamiliar drug names. Further to these positive outcomes, the overwhelming majority of students recommend DrugSpeak be used in future iterations of the 2009PHM course (92.3%) and that it should also be embedded within other health degree programs (88.5%).

Student pronunciation performances in audio recordings

Analysis and comparison of the pre- and post-recording audio files following the DrugSpeak program revealed that student drug name pronunciations were significantly more accurate (p = <0.001) and fluent as measured by being faster (p = <0.001) and making fewer attempts (p = 0.002) (Table 2). The mean number of drug names pronounced correctly before DrugSpeak was 75.5 out of a total of 108 drug names (69.9%) and this increased to 85.5 out of 108 drug names (79.2%) after DrugSpeak.

Table 2
Audio analysis of pre- and post-recordings and their comparison. SD = standard deviation.

Pronunciation parameter	**Pre-recording score (mean ± SD)**	**Post-recording score (mean ± SD)**	**Difference (mean ± SD)**	***p***
Accuracy (%)	75.5 ± 14.7	85.5 ± 15.1	-12.0 ± 14.4	<0.001
Average time per word (seconds)	3.6 ± 2.9	2.77 ± 1.8	-1.1 ± 2.5	<0.001
Attempts per word	1.3 ± 0.7	1.2 ± 0.2	-0.1 ± 0.2	0.002

Accuracy of matched Treated, Untreated and New Word sets

The audio recordings tested drug names that were studied during the DrugSpeak program (Treated drug set), drug names not included in the program (Untreated drug set) and unfamiliar names of drugs not yet released to the market (New drug set). Student drug pronunciations showed improvement in all three of these matched word sets following DrugSpeak. Specifically, the Treatment drug set showed an 18.8% increase, the Untreated drug set yielded a 18.2% increase, while the New drug set showed a 27.2% increase. Statistical analyses using the McNemar chi-square test revealed a significant proportional increase in accuracy for the Treated set (χ^2 = 150.693, p = <.001) and Untreated set (χ^2 = 79.314, p = <.001, however this was not found for the New Word set (χ^2 = .379, p = .538).

Discussion

This work represents the first study of its kind in that is uses a drug pronunciation learning program to directly assessing the perceptions and capabilities of a Pharmacy student cohort in pronouncing drug names. Our findings demonstrated that the DrugSpeak Program could deliver significant improvements in drug pronunciation in terms of accuracy, suggesting that it increased student proficiency in decoding and encoding drug names to generate verbal fluency. The study differs from many other pronunciation research articles in that it focuses on the explicit pronunciation of single drug names, rather than drug name recognition or recall, as is the case with LASA drugs. The quality of student pronunciation of short sentences and paragraphs has been assessed [29], but even in this case student language awareness shows improvement, but not pronunciation skills. A recent study utilised a cloud computing model to compare student English pronunciations with reference word pronunciations in real time, to produce continuous pronunciation quality assessments [30]. While these represent an attempt to provide general improvements in student verbal English performances, the DrugSpeak Program focuses on drug name pronunciations as an important graduate attribute that is specific to future health professionals.

DrugSpeak also produced almost identical increases (~18%) in student proficiencies in pronunciations of drug names that were included within the course learning material (Treatment drug set), as well as drugs not included in the course (Untreated set). This may have been driven by a global enhancement of student strategies in drug pronunciations, rather than improvements in drug names that are more familiar. Nonetheless, some item-specific effects from exposure can be argued as the Treated drug names had higher chi-square values suggesting a greater effect. Interestingly, students showed even greater increases (27%) in pronunciation ability for drugs not yet on the market and this were completely unfamiliar to them (New Word set), however this increase was found to be insignificant. Again, it is possible that non-specific increases in skills caused this response. However, only 10 drug names were included in the New word set, and research has revealed that a small samples size may influence research outcomes which could produce a non-significant increase, contrary to observation [31].

Factors such as student gender or native language were not primary parameters of focus in this report. Studies are inconclusive on gender since pronunciation ability is multifactorial [32, 33]. One may assume that native language may predict drug pronunciation ability, however all students are required to meet minimal English language levels upon entry to university. Furthermore, drug names hold a cross-similarity to the English language as there are no drug names that fall outside the (approximate) 45 sounds produced in the English language [34]. As such, factors outside of gender and native language are likely to have more impact on drug pronunciation ability. One example may include prior learning, such as phonetics training in secondary schooling, and student motivation and attitudes towards the importance of correct drug pronunciations in their desired careers.

Students were surveyed on six paired questions both before and after the DrugSpeak program on their perceived confidence, anxiety, learning ability, and competence of other health professionals in terms of drug pronunciation. Only those questions pertaining to student confidence and learning ability

demonstrated significant improvements following DrugSpeak. This indicates that DrugSpeak equipped students with the strategies and approaches they needed for correct drug pronunciations, translating to increased student confidence and ability to learn in this regard. This is supported by the data in our study which showed increases in student drug pronunciation accuracy. Indeed, higher levels of student self-confidence leads to enhanced performances and increases in positivity in problem-solving [35]. Contrastingly, statistical differences were not observed for student questions relating to the importance of drug pronunciation and competencies of other health professionals. This is likely due to the high baseline levels of these perceptions prior to intervention with the DrugSpeak program, revealing the generally high level of value placed on drug pronunciations by Pharmacy students even prior to the use of DrugSpeak.

The overall feedback from students on the DrugSpeak Program was very positive. Most participants agreed that it increased their knowledge of phonetics and that it enhanced their confidence in drug pronunciations. Additionally, students recommended DrugSpeak be incorporated into the curricula of the course for future students and even introduced into coursework of other health degree programs. We are currently integrating DrugSpeak into our postgraduate degree program and seek to further broaden its impact by incorporating it into the Medicine and Nursing degrees. Ultimately, we anticipate that this will reduce the frequency of medication errors within the health sector, with enhancements in health practitioner fluency have downstream effects of higher patient satisfaction and quality of care [39].

Further complications arise in spoken pronunciations of drug names due to the requirement for health professionals to wear surgical masks [37]. This factor is more prominent than ever given the emergence of the Covid-19 pandemic. Since masks obscure the mouth, reduce voice projection, and reduce articulatory clarity to a degree, they add to the confusion as to which specific drug medications are being spoken by the mask-wearers [38]. This is further hampered by the noisy work environment and other distractions that are common in crowded pharmacies and various clinical settings [3, 12, 39] where clear, precise verbal drug communication practices are essential. Drug pronunciation programs such as DrugSpeak seek to provide further assistance in this regard to prevent medication errors that arise from mispronounced drug names.

As the DrugSpeak program was a pilot study, there were several limitations to this study which should be addressed in future iterations of the program. Firstly, a control group of students who possess minimal exposure to drug names (e.g. students enrolled in programs unrelated to medicines) may help determine the effects of the program on drug pronunciation. Secondly, prior exposure of students to drug names through popular culture, advertising, previous drug-related work or study, own prescription drug use or awareness may all contribute to baseline proficiencies in drug pronunciations. This should be accounted for when collecting sociodemographic data in future. Thirdly, levels of student exposure to drug names between the first and second audio recordings should be standardised, as this is likely to directly influence student performances in the second recording. This may be difficult to control, as it is dependent upon student motivation and attitudes towards drug pronunciations. To remedy this, it may be necessary to conduct the final audio recordings immediately following the DrugSpeak workshops rather than during the final week of the course.

Conclusions

The DrugSpeak Program was a pilot study that sought to address deficiencies in student drug pronunciations within a Pharmacy cohort. The findings indicate student awareness of the need to address this problem, and that the program itself increased their confidence and reduced their anxiety in terms of drug pronunciation proficiency. Audio recordings revealed significant increases in student drug pronunciation performances in terms of accuracy and fluency, and this occurred for drug names that were studied in the course as well as unfamiliar drug names. Further studies will be aimed at testing DrugSpeak in other health-related degree programs to further examine its effectiveness and extensibility, as well as its ability to reduce medication errors in the health sector.

Abbreviations

LASA: look-alike, sound-alike

STEM: Science, Technology, Engineering and Mathematics

Declarations

Ethics approval and consent to participate

Student participation was voluntary and research data collection required signed consent. Ethics approval was obtained from the Griffith University Human Research Ethics Committee (GU Ref No: #2018/238).

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare no completing interests.

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Authors' contributions

DD conducted the experimental analysis and EC delivered the DrugSpeak workshop. MC and SA collected the data, and MC was a major contributor in writing the manuscript. All authors were involved in the original idea and project design, and well as the proofreading and approval of the final manuscript.

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Figures

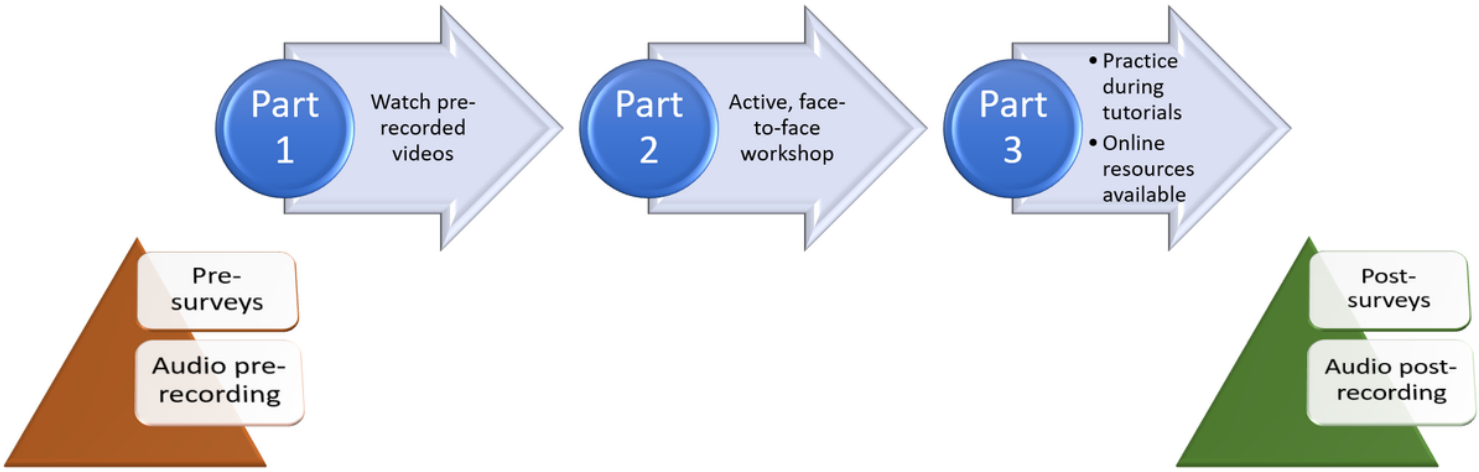

Figure 1

Timeline of the DrugSpeak project. Students completed surveys and audio recordings prior to watching pre-recorded videos on drug pronunciation (Part 1) and the DrugSpeak workshop (Part 2). Students could practice drug pronunciations during tutorials held during the course and given access to audio files containing drug pronunciations for all drugs studied during the course (Part 3). Finally, post-surveys and audio recordings were conducted towards the end of the course.

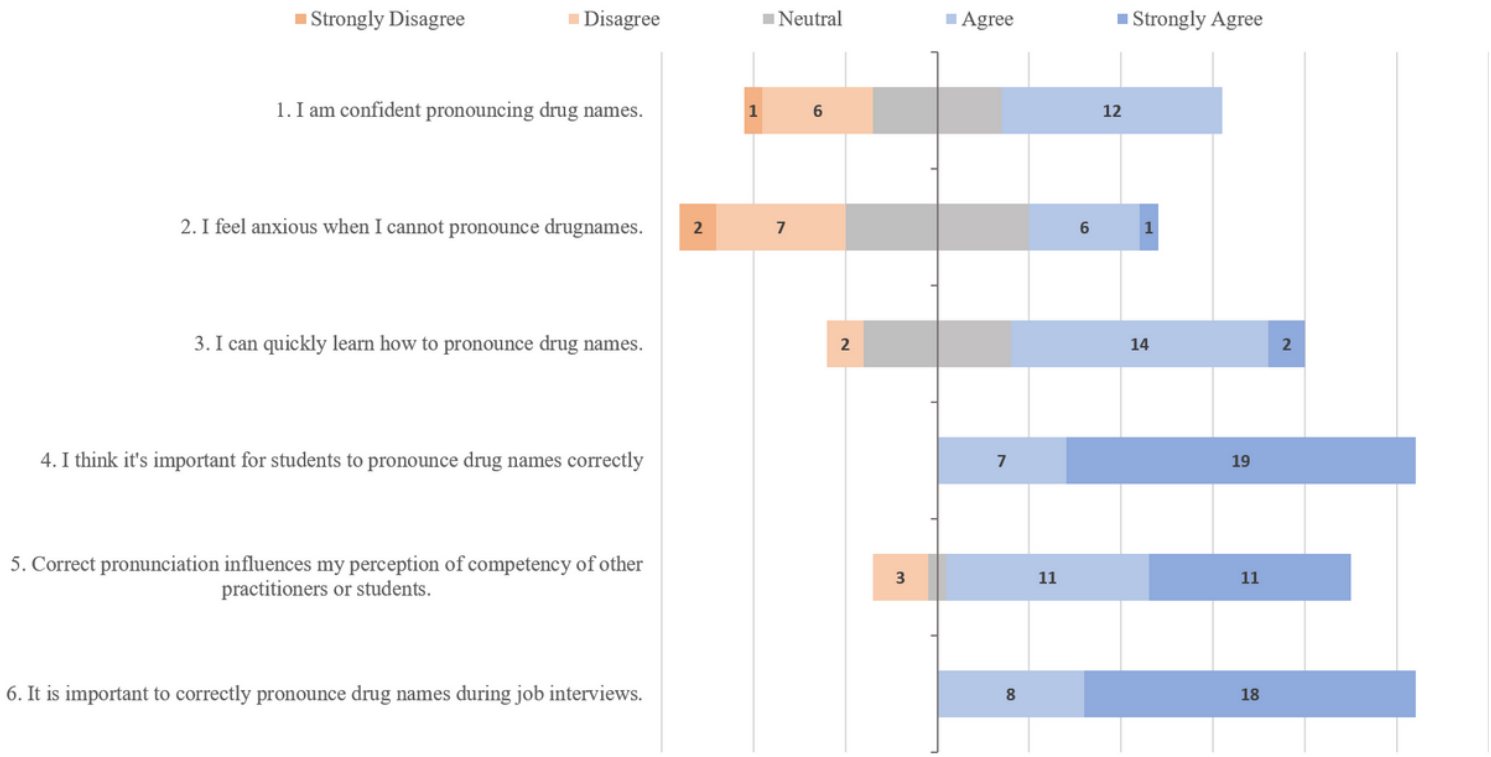

Figure 2

Pre-survey questions and student responses. The total number of students was 26. A right skew (blue and dark blue) indicates positive agreement while a left skew (orange or dark orange) indicates disagreement. Neutral responses (grey) are shown spanning the central line. The size of each category is proportional to the percentages of responses.

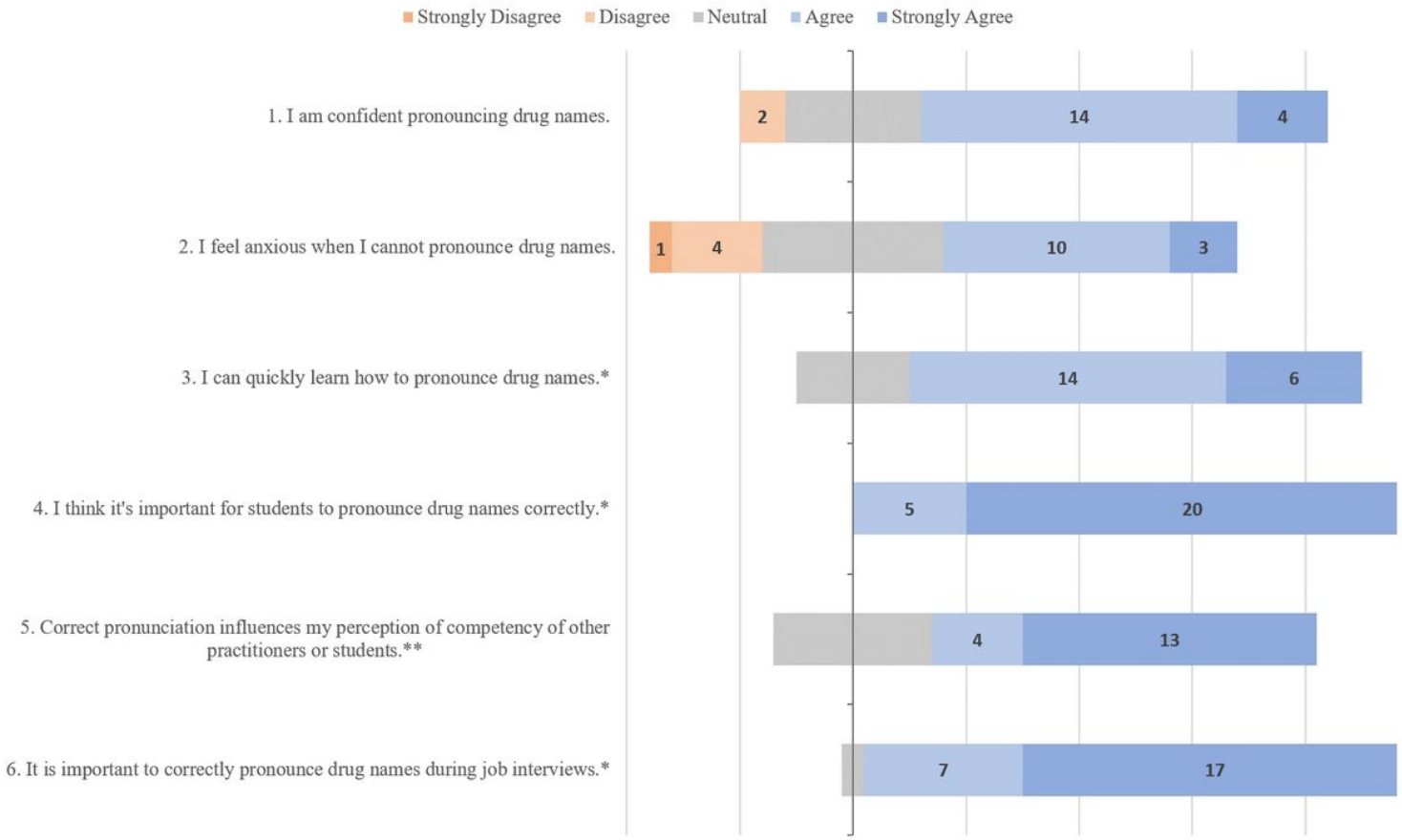

Figure 3

Post-survey questions and student responses. The total number of students was 26. A right skew (blue and dark blue) indicates positive agreement while a left skew (orange or dark orange) indicates disagreement. Neutral responses (grey) are shown spanning the central line. The size of each category is proportional to the percentages of responses. * indicates that there was one missing response, ** indicates that there were two missing responses.

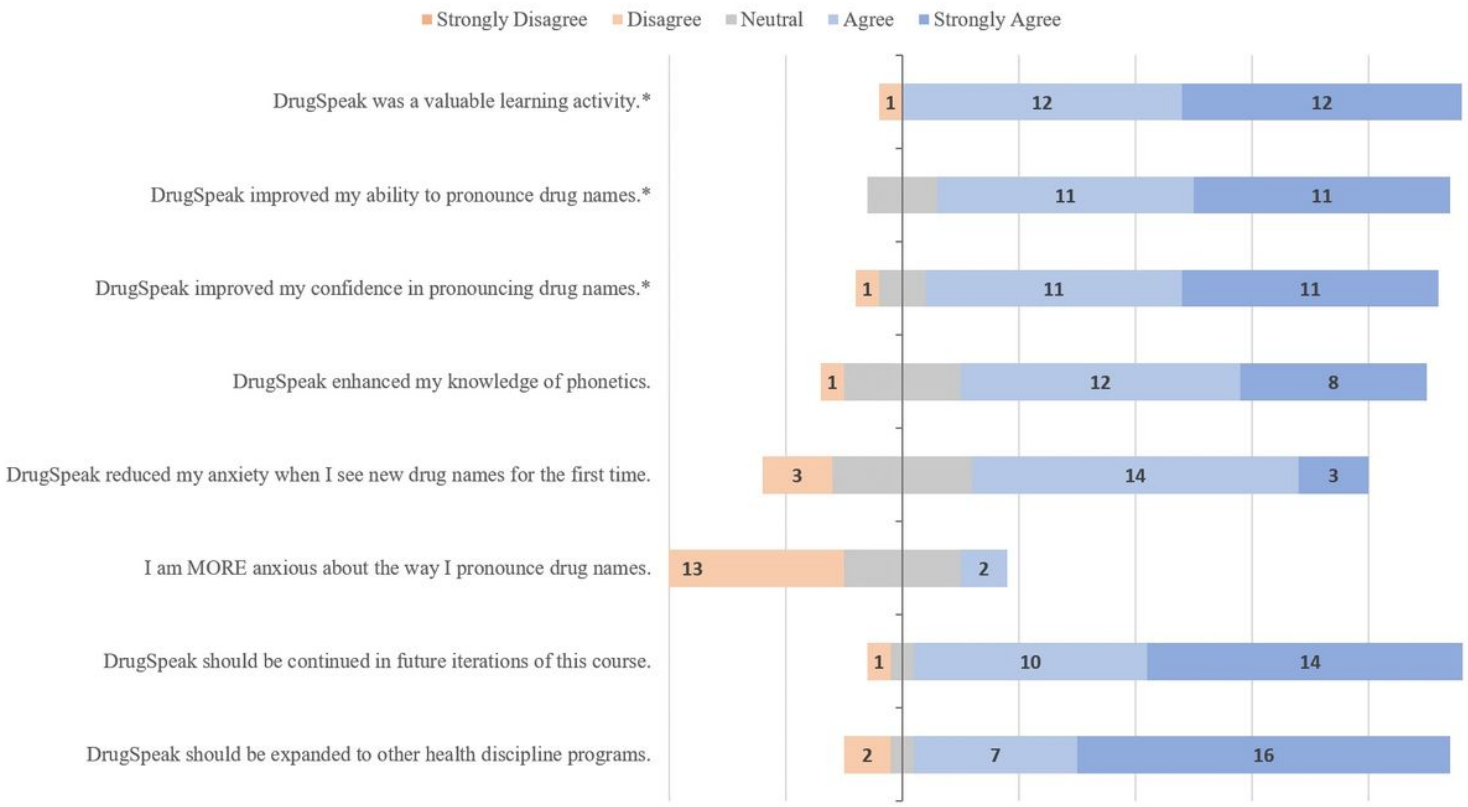

Figure 4

Third survey data revealing general student feedback on the DrugSpeak learning activity. The total number of students was 26. A right skew (blue and dark blue) indicates positive agreement while a left skew (orange or dark orange) indicates disagreement. Neutral responses (grey) are shown spanning the central line. The size of each category is proportional to the percentages of responses. * indicates that there was one missing response.