# Title: Spaced-Repetition Learning as a tool in medical education – A co-creation session

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## *Abstract*

**Background:** NIL

**Objective:** Too much to learn, and not enough time - this growing phenomenon has been a constant challenge in medical education. This study aimed to examine the usefulness of Spaced-Repetition Learning (SRL) as a learning tool for Medical Students.

**Methods:** An online co-creation session was organised for a Singaporean Medical Student Organisation. Participants (n=9) were first educated on SRL Theory and invited to explain barriers they faced using SRL (Anki). Subsequently, they participated in a co-creation process making ‘basic’, ‘cloze’ and ‘occlusion’ cards based on 1 month pediatric milestones. Participants were surveyed on whether Anki benefited them.

**Results:** “Active Recall” was the most common answer when asked “What does Anki mean to you?”. Others include “tedious” and “my bread and butter”. Barriers to start included perceptions of ‘time-consuming’ and a ‘steep learning curve’. Most students used Anki for Medicine (57.1%), Surgery (57.1%), Anatomy (42.9%), Physiology (42.9%), Paediatrics (28.6%), and Obstetrics and Gynaecology (28.6%)

**Conclusions:** SRL software continues to be a prominent tool for medical education. Identifying specific barriers students face, we incorporated coaching and democratic leadership styles using Roger’s Diffusion of Information Theory and addressed these concerns through group discussion and active participation.

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# Original Manuscript

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**Author Note:**

We have no known conflicts of interest to disclose. We agree to pay for the APF.

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# Abstract

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Conclusions: SRL software continues to be a prominent tool for medical education. Identifying specific barriers students face, we incorporated coaching and democratic leadership styles using Roger’s Diffusion of Information Theory and addressed these concerns through group discussion and active participation.


**Bullet Points**

**1. SRL software challenges both education power structures and promotes social transformation**
**2. Student-led initiatives continue to be a mainstay in medical education**
**3. Mounting academic pressures are forcing medical students to adapt to cover all of the content**
**4. Roger’s DIT plays an important role in Medical Education Innovation.**

# Introduction

Too much to learn, and not enough time - this phenomenon has been a constant challenge in medical education. For decades educators have debated what to include and exclude in the medical curriculum. In making any decision they also inherently emphasise certain aspects of a course, while denoting the lack of importance of other areas. Contributing to this issue is, paradoxically, our advancements in healthcare. A better understanding of underlying physiology and pathophysiology, wider and more holistic care definitions, and novel therapeutic and treatment alternatives all force their way into a curriculum with the aim of bettering patient-centred care (Slavin and D'Eon, 2021). Additionally, as discussed by Grant (2013), we must also be cognisant of other factors necessary in medical curriculum including local generational needs, trends in learning theory, and shifting social and political situations. To further compound issues, there have been different philosophies and methodologies regarding how to provide a good education to medical students. For example, Flexner

promoted university based education with particular emphasis on the basic sciences, while Osler advocated for learning through practice with direct patient content and expertise from clinicians (Buja, 2019). All in all, the medical curriculum is larger than ever in trying to provide for a broad and deep knowledge base, skill set, and competencies.

This extensive and evolving medical curriculum has forced reactive coping strategies as well as triggering innovative solutions. Unfortunately, as a consequence of the sheer amount of workload present in the medical curriculum, medical students, and faculty are all too familiar with stress, burnout, and mental health struggles. The trends are rather alarming, with a systematic review and meta-analysis by Rotenstein et al. (2016) indicating that 11% of medical students internationally suffer from suicidal ideation, while when looking at faculty, we see high burnout rates, something which is also linked to individual willingness to adapt to the medical curriculum (Arvandi et al., 2016). Such figures haven't gone unnoticed, and educational institutions and professional bodies alike should be applauded for introducing a range of facilities and coping strategies. While I am acutely aware that this reactive process does not address the underlying issue, such present strategies and overt recognition of the aforementioned consequences are a necessity for future advancements. In addition to this, students themselves have also created innovations to facilitate their knowledge requirements for assessments. As in any educational organisation, student strategies to address curriculum issues must take different forms. This is due to numerous factors including power imbalances in implementing any process in a larger organisation, lack of individual student resources, and need for rapid and marked successful innovation implementation for the individual student in question. Thus, students, in accepting that they will not be able to quickly, or perhaps even effectively, change the curriculum, in some form or another, ask themselves "How can we learn so much content without forgetting?".

To address this, several students have turned to spaced-repetition learning (SRL). More specifically, medical students have adopted SRL software platforms to facilitate their learning needs for information organisation, retention, and recall. These programmes aim to digitise all student learning materials and to remove the demand for students to know what they do and don't remember. This is done by testing students on the content they require and only when they require it. The ideology of SRL is based on active recall, a study technique which uses explicit student-led self-testing as a form of learning. This is in contrast to the traditional student view of testing, which, as described by Augustin (2014), can oftentimes be seen as an instrument of power used by faculty as the sole means to assess previously acquired knowledge. The most common of these platforms used by medical students worldwide is "Anki", named after the Japanese word for memorisation " ". Current estimations of medical student numbers in the USA using this platform rest at >68.3% (Halperin et al., 2024). This rate of adoption has been due to several factors. Such examples include a 6-12% point increase in first year medical student grades (Gilbert et al., 2023), a positive dose-response effect to standardised tests such as USMLE scores (Lu et al., 2021), and better perceived sleep quality (Wothe et al., 2023). However, despite widespread use and apparent benefits of SRL software, students face barriers to implement such tools.

Thus, I present my project titled "Spaced-Repetition Learning as a tool in medical education – A co-creation session". In this project we aimed to provide medical students the tools to access, use, and collaborate on SRL software. To facilitate this, we developed an online co-creation venture to identify the specific barriers faced by these students, and to enable them to address these concerns through group discussion, peer and teacher examples, as well as active participation.

# Methods

## Overview

I collaboratively developed an online co-creation teaching session. The intervention was collectively aimed to help medical students use the SRL software Anki as a tool for their unique learning needs. The session lasted 1 hour, and included discussions and synergistic student-teacher instruction. More specifically, the discussion topics of SRL theory, estimations of fellow student Anki use, and individual barriers faced, were based on the information provided by students through an interactive slideshow software programme, Slido. Moreover, student-teacher instruction and associated dialogue stemmed from live demonstrations of the Anki application through general use, deck and flashcard creation, as well as setting optimisation. Specific tasks were given to both students and I. I used a single piece of information, namely, the one month gross motor paediatric milestones, which was chosen by the students, and created 3 common types of flashcards - basic, cloze, and image occlusion. To conceptualise this, Basic flashcards have a question on the front with the answer on the back, akin to a normal physical flashcard, while image occlusion is specifically used for labelled diagrams. By contrast, cloze deletion is founded in the work of Taylor (1953), requiring students to insert the correct word from the literary context, although, as demonstrated by our student examples, this is open for artistic interpretation. The students were tasked with making flashcards for 3 pieces of information. Namely, the definition of a hernia, the dermatomes of the arm, and a Parkinson's disease mnemonic. Students and teachers illustrated and discussed their choices in flashcard development for the tasks presented. Feedback was sought before, during and after the intervention.

## Co-creation process

The co-creation ideology was based on enabling a social transformative process. This is inspired by the works of Freire (1968) in the infamous "Pedagogy of the Oppressed". Instead of providing a prescriptive set of resources for the students to force into their routines, I, instead, prioritised a peer-led process to empower students to incorporate their SRL tool of choice into their study habits, as they see fit, in medical school and hopefully, through transferability, into the future in different domains of life. To allow for such a process, I endeavoured to find partners to attempt to give a representative sample of a variety of universities across Ireland. Consequently, the co-creation aspect of this project was developed in partnership with the Singapore Medical Society of Ireland. I reached out to them and discussed my proposed ideas for a project. Prior to this interaction I reached out to other university societies, namely, University College Cork's Medical Research and Technology Society and the Royal College of Surgeon in Ireland's Paediatrics Society with no success. My main point of contact with the Singapore Medical Society of Ireland was the education representative on the committee, who was in close and frequent discussion with their fellow committee members and wider general membership. After deciding on an online teaching session for Anki, we next sought further contributions from the society membership. This was assisted through social media posts, online group chat distribution via WhatsApp, and an online survey shared through the Google Forms platform. Results from this survey, and dialogue from the society committee aided in formulating the teaching session. Additionally, multiple reviews of the teaching session slides, content, and layout took place before implementation. Moreover, the feedback received throughout the process has the potential to aid future collaboration, teaching development, and further strengthening student participation. Looking at this co-creation process more critically in the wider literature, our project failed to provide a comprehensive whole class model of inclusion. Such a system, as reviewed by Bovill (2020), would have permitted stronger positive relationships more broadly by fostering greater teacher-student interaction. However, this implementation also leaves itself exposed to the

threats of time constraints and a large student cohort. As such, and in echoing Bovill (2020), we perhaps employed a different power dynamic by utilising a society as a proxy for true individual student engagement. Finally, to specify, decisions which were directly fabricated out of the co-creation process included:

- Time allocation of the event.
- Using Anki as the SRL software of choice as it is perceived as the most popular option among medical students globally, has little to no financial burden, and has a large community-driven network for content creation and troubleshooting which is enhanced by its open-source coding principles.
- Ensuring the session was held online to cater for other student commitments and to limit travel costs.
- Making flashcards during the session to demonstrate ease of use;
- Allowing time for troubleshooting.
- Enabling space for honest and open discussions about addressing barriers to Anki implementation as a study tool.

### Population

The population of interest were members of the Singapore Medical Society of Ireland, or as it's more affectionately named "SMSI". Membership includes Singaporean undergraduate and postgraduate medical students from across Ireland. Membership is not limited to Singaporean citizens, and can include Singaporean residents. University affiliation and year of study of those registered for the intervention are illustrated in the results – demographics section. Demographics of attendees was not taken.

### Data management

Data was acquired at different stages of the intervention development process and implementation. The online survey software platform Google Forms was used during the design process, as well as for the end-of-session and follow-up feedback surveys. Complementing this, Slido, an interactive slideshow software programme was used to gather data during the intervention. No personal identifiers were gathered or stored during either of these processes to minimise data protection concerns. Students had the option to display name, and/or live video feed as part of their participation through the online video conferencing software, Zoom. None of these identifiers were compulsory in respecting participant privacy, nor was such data recorded.

### Data analysis

Data was analysed in real time by the software programmes Google Forms, and Slido for their respective data only. This was done to enhance efficiency for data collection, storage and interpretation. No additional software applications or manual methods were used to analyse the data to bolster transparency given the small sample size.

# Results

### Demographics

Demographic data was taken during the initial registration for the event (n=25). This does not reflect actual participants during the learning session (n=9). The majority of students who initially registered were in 1$^{st}$ year of undergraduate medicine (56%), while other students were also registered from 2$^{nd}$ year (12%), 3$^{rd}$ year (16%), and 4$^{th}$ year (12%) undergraduate medicine. There were no students from

final year undergraduate medicine, but there was 1 student from graduate entry medicine. Additionally, Trinity College Dublin was the most represented university at 88% of those registered. This was followed by the Royal College of Surgeon in Ireland at 8%, and the National University of Ireland, Galway at 4%. Demographic data was self-produced by students without verification.

Student perceptions

"Active Recall" was the most common answer when asked "What does Anki mean to you?". Other responses demonstrated varied themes from "tedious" to "my bread and butter". This data is illustrated in detail in *figure 1*. Furthermore, the dominant student estimations of Anki users among peers were between 40-60% (n=4, 50% of respondents), with 25% of students estimating this figure to be between 60-80%, and 12% of students thinking either 20-40% or 80-100% use Anki. In addition to this, barriers identified by students acknowledge the steep learning curve of Anki, challenges with making effective and efficient flashcards, and difficulty around time management and consistency. Further details are present in *figure 2*. Finally, 100% of students (n=9) thought Anki was an innovative or very innovative study technique.

Flashcards

Displayed in *figures 3-5* are examples of the flashcards created by students during the teaching session. Flashcards were generated using basic *(figure 3)*, cloze deletion *(figure 4)*, and image occlusion techniques *(figure 5)*. Flashcard content was not verified by myself or a third party for accuracy. Content used by students was not checked for copyright breach.

Feedback

100% of students found the learning session useful, and were likely or very likely recommend it to other students. Moreover, at the end of the teaching session 88.9% of students stated that they were likely (n=2) or very likely (n=6) to use Anki as a study technique, with only 1 student neutral in their response.

Innovation utility and follow up

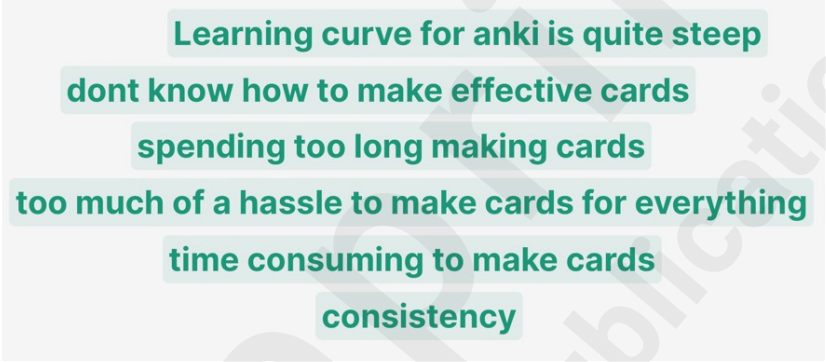
I sought follow-up for the innovation intervention 1 week after the learning session. In this survey, 57.1% of students (n=4) had started using Anki, and an additional 14.3% (n=1) stated that they would start using Anki soon. Consequently, 26.6% (n=2) had not started using Anki at this time. Looking at the data more deeply, the most common subjects students were using Anki for was Medicine (57.1%), Surgery (57.1%), Anatomy (42.9%), Physiology (42.9%), Paediatrics (28.6%), and Obstetrics and Gynaecology (28.6%). Finally, 28.6% of students (n=2) had started their own unique study groups as a result of this intervention.

# Figures

***Figure 1:*** Word cloud of "What does Anki mean to you?"

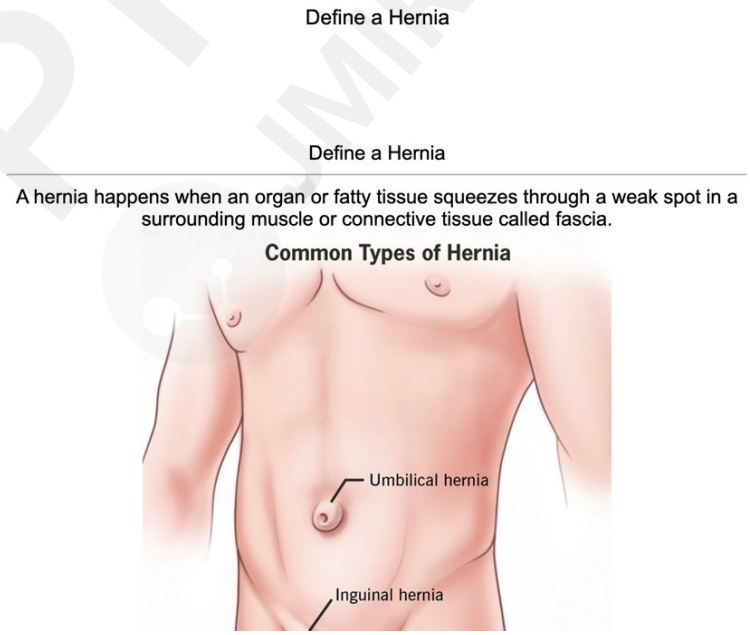

Responses were conducted anonymously. Multiple responses were allowed. Answers were only shown collectively after responding. Student participation n=6.

***Figure 2:*** Word cloud of "What have been your barriers to using Anki?"



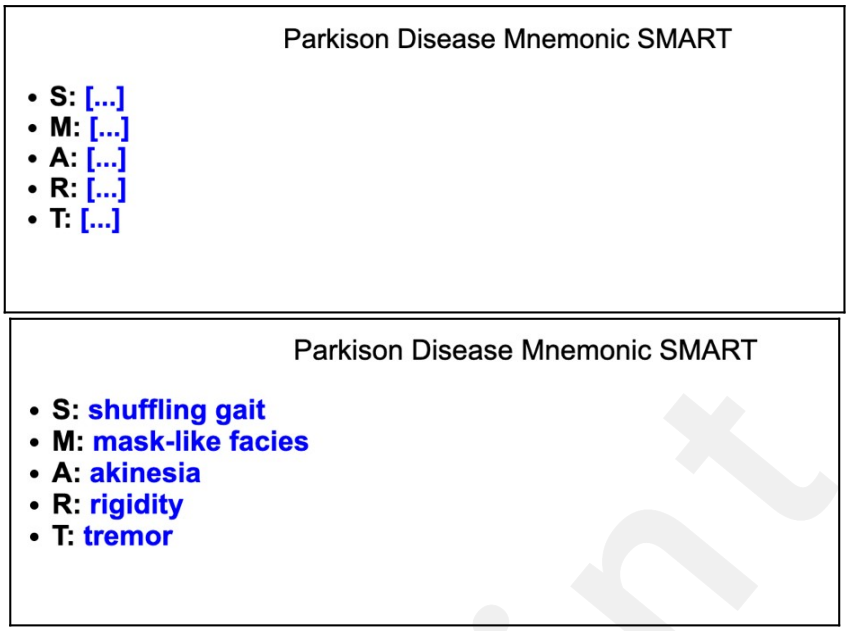

Responses were conducted anonymously. Multiple responses were allowed. Answers were only shown collectively after responding. Student participation n=6.

***Figure 3:*** Basic flashcard defining a hernia



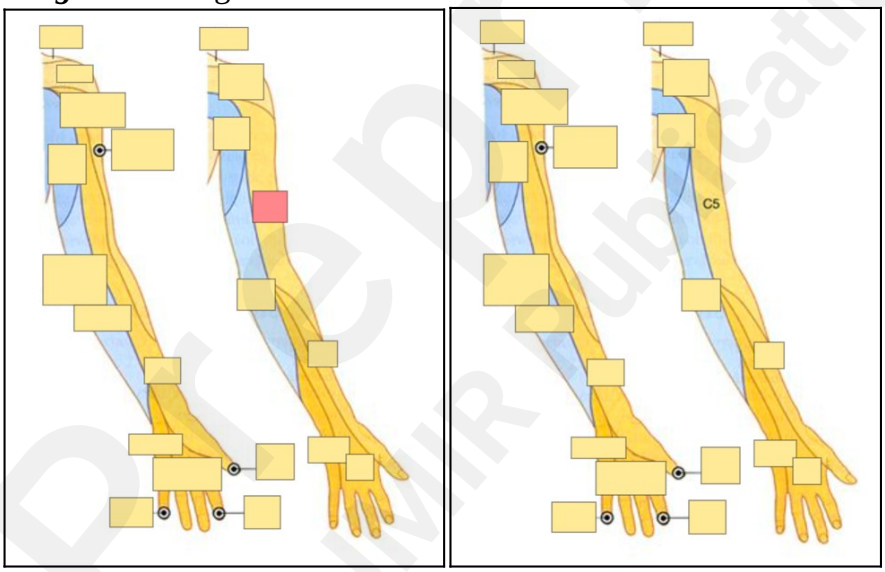

Front and back of flashcard denoted by continuous black line.

***Figure 4:*** Cloze deletion flashcard of a Parkinson's Disease Mnemonic




Front and back of flashcard denoted by continuous black line.

***Figure 5:*** Image occlusion flashcard of dermatomes of the arm




Front and back of flashcard denoted by continuous black line. Red box indicates the target information. Yellow boxes illustrate future flashcard to be tested.

# Discussion

To understand the multiple facets of this project, we will utilize established innovation theory to enhance and structure our discussion. Prima facie results from this small-scale study indicate that SRL software platforms prove again to be popular among medical students. Several factors exist which may have influenced the positive attitudes expressed by students. These include co-creation process, directly addressing the barriers students faced, or enabling collaborative learning. However, such open dialogue lends itself to bias and makes comparison to other innovation in the wider literature more challenging. To aid this process, we will use an established innovation framework in order to characterise, detail, and analyse our project into its component parts. As examined by Correia (2018), there are several innovation models to choose from, common examples of which include the technology acceptance model, Rogers' diffusion of innovation (DIT) theory, the chocolate model, and Hall's concern based-adoption model. Looking specifically at our needs, it is perhaps apt to consider a model with more generalisable and widespread innovation application. With this in mind, Hall's concern based-adoption model has the least utility in our setting as it's based on a standardized questionnaire for educators, likewise, while the chocolate model is more broad, it is also relatively new in its implementation in the innovation domain. Additionally, the technology acceptance model, while widespread, has a narrow focus on potential adopter's perceived utility. Thus the best candidate for our needs is Rogers' DIT model which uses several approaches to describe the state of an innovation. These include the adopter categories from innovators to laggards, and the variables determining the rate of adoption including perceived attributes of innovation adoption, the type of innovation-decision, communication channels, the surround social system, and promotion efforts. Therefore, given Rogers' DIT clear and detailed framework, along with its widespread use across innovation literature, we will use it as the basis of our discussion going forward (Rogers, 2003). More specifically we will first discuss how our project fits within the perceived attributes of innovation adoption, before later looking at the variables determining the rate of adoption more broadly.

## Perceived attributes of innovation adoption

The perceived attributes of innovation adoption as described by Rogers, illustrates the popularity of SRL learning. Areas which promote SRL adoption are those, as categorised by Rogers, of relative advantage, trialability, and observability, while compatibility, complexity may be seen as barriers. Relative advantage reflects how the novel innovation supersedes the previous employed utility. In this respect the relative advantage of Anki is its ability to store, organise and facilitate a tailored learning experience for the user. This perhaps directly replaces other forms of electronic note keeping, but with the added benefit of software prompted active recall through algorithms which adapt to the user's individual relationship with each flashcard. Moreover, Anki's shared platform design initiates collaborative learning among peers and the wider public with flashcards available across a wide range of topics from university education to languages. With this in mind, it's possible to deduce that Anki attempts to enable a social transformative process akin to Freire (1968) by democratising information rather than relying on prescriptive narratives from established power structures. In this capacity, Anki, thus, empowers a community of students either among peers or even globally in a collective strive for success in their chosen domain. The size of this community was reflected in our results, with our aforementioned estimations of the majority of medical school students now using Anki consistently in their study routines. Additionally, supporting the perceived relative advantage by students is our study which saw a narrow majority of students already implement Anki within 1 week across a range of subjects. Aiding this is Anki's ability for trialability

and observability. Given Anki's financially free service agreement on computers, and its widespread operating system implementation students have the ability to trial and experiment with Anki without consequence. This was also evidenced during the co-creation process. On reaching out to students it was clear that a notable majority of students, while not daily active Anki users, had varying levels of experience with the platform. One aspect however, where students had varied information was in observability *(figure 1)*. This, as described by Rogers indicates the degree to which potential adopters can see the results of the innovation in practice. While, not a direct barrier identified by students in the development of this project, we did discuss SRL theory, common uses of Anki for medical education, and its more famed results in increasing test scores (Gilbert et al., 2023, Lu et al., 2021) and improving perceived sleep quality as previously mentioned (Wothe et al., 2023).

However, several attributes continue to be significant considerations for the introduction of Anki as a study technique. These take the forms of compatibility, and complexity. Compatibility refers to the perceived consistency with existing utility, values and experiences. In this respect, Anki is perhaps far removed from this ideology. Instead of classic note taking, summarising and application of this information through patient interaction, Anki adopts a fact-based, or, if you will, "Gradgrind" approach to education and exploits the reductionist trends of product-based curricula (Dickens, 1854). Thus, to fully employ Anki as an isolated study tool for medical education would require the ability to identify and subsequently break down all skills, attributes and values of being a medical professional into digestible information. While perhaps initially perceived as an impossible feat, this is arguably the basis of modern competency based education (CBE) as discussed by Frank et al. (2010). CBE has now become the dominant curriculum model in medical education. This shift, as eluded to by Carraccio et al. (2002), had several critics throughout its implementation such as how to define competence, and how to develop reasonable assessments. While today, similar criticisms of CBE continue to persist, with Frank et al. (2010) notably outlining the threats of reductionism, loss of authenticity, promoting the lowest common denominator, tyranny of utility, and logistical chaos. With this, I think it's also reasonable to suggest that Anki, through the combination of democratisation and reductionism, is a consequence of, if not inspired and promoted by, medical education's current mandate for CBE curricula.

Complementing this is the other significant barrier for students attempting to integrate Anki as a study tool - complexity. Rogers described complexity as the extent to which an innovation is perceived as difficult to use. This was a major barrier which we identified in our project. As illustrated in *figure 2* students clearly stated that Anki has a steep learning curve, that they didn't know how to make effective flashcards, and that they were spending too much time on flashcards. To directly address this we trialled live demonstrations by student and teacher of Anki flashcard creation which was complemented by discussion as detailed in the methods. The success of this targeted intervention, coupled with the co-creation process which catered for the students' needs is likely reflected in the positive feedback received. Developing on this, and looking to the future, there are currently a range of artificial intelligence products coming to market to accompany Anki, and other SRL software platforms, with the aim of reducing these aforementioned barriers by the creation flashcards with minimal student involvement (Pendergrast and Chalmers, 2023). While certainly a curious evolution of this innovation, there remains sparse literature around these advancements to comment further.

Other variables determining the rate of adoption

We will now shift our focus to the other variables determining the rate of adoption as theorised by Rogers, namely 1) the type of innovation-decision, 2) communication channels, 3) the surround social system, and 4) promotion efforts. Firstly, looking more closely at the innovation decision, there are facets which apply directly to our innovation through the process checkpoints of

knowledge, persuasion, decision, implementation and confirmation. More broadly, students who use Anki adopt both collective and optional decisions as opposed to one of authoritative instruction, in a socially transformative process to combat the rising tide of information overload, CBE and other wellbeing considerations. These social and collective powers are seen in the knowledge, information, and implementation stages of Anki, as aided by its community-led learning endeavours and open-source coding. Enhancing these factors is perhaps the strongest benefit of our teaching session, which mimicked these attributes but in a more personal and targeted approach towards the unique student barriers we identified in our cohort. Further integrating this community of learning promoted by Anki, is the communication channels and social system. This is clearly evidenced through our project with peer estimations of Anki users upwards of 50%. A figure which, as touched on previously, is certainly reflective of SRL software use among medical students in the wider literature (Halperin et al., 2024). Furthermore, I would also like to bring your attention to the 2 unique study groups which were created as a result of our intervention which only expands the positive collective learning communicative social systems in Anki. Finally, in resonating with change agents' promotion efforts as per Rogers' model, there is a palpable movement across the medical student cohort towards the use of SRL software. To best facilitate this very much communal innovation, as a change agent, I adopted a mix of coaching and democratic leadership styles (Goleman, 2000). These styles, I found, complemented each other nicely by enabling students to recognise that they could overcome some of the barriers they identified with Anki, while also encouraging students to have an open dialogue about their challenges and providing them the opportunity to solve said challenges.

**Limitations**

Despite the positive results identified by this study, design and logistical limitations weaken extrapolation. The main design criticism is manifested through the small and non-representative sample. Initially, as touched on previously, I targeted larger and a more diverse cohort of students from a variety of universities and associated societies. It's difficult to understand why such an initiative was rejected by these stakeholders, especially given the student-led and minimal resource prerequisites of this project. Furthermore, logistically, I fear that the temporal positioning of this event was harmful to its success, with students, I postulate, perhaps more keen to introduce novel study tools at the start of a semester. This could be accounted for in the disparity between those initially registered and those who attended the teaching session. Moreover, additional time between innovation implementation and data collection may have yielded a better representation of Anki use.

**Conclusion**

To conclude, it is clear that SRL software, despite its barrier, will continue to have a prominent place as a tool for medical education. Illustrating this, we developed, through a co-creation venture, an online learning session on SRL software for medical students. More precisely, we identified the specific barriers faced by these students, and using a combination of coaching and democratic leadership styles enabled them to address these concerns through group discussion and active participation. Fundamentally, however, this intervention will have given students a study tool for them to employ for their educational needs. Complementing this practicality, we examined this project through innovation theory using Rogers' DIT framework. This permitted us to interrogate the varied and intricate factors which have been involved in the implementation of SRL in our intervention and the wider public. By virtue of this discussion, we argued that SRL software not only challenges existing prescriptive educational power structures, but also promotes a social transformative process through its focus on the democratisation of information and the philosophy of reductionism. Despite this, while we, as educators, should continue to strongly advocate for the establishment of these student-led initiatives, we also caution that these solutions were developed as a consequence of the current trends of product-based education systems and the strenuous demands placed on students. Finally, we must acknowledge that such reactive innovations will continue to be

developed in response to the educational pressures placed on students, and this should thus push educators to actively reflect on the factors that sparked their development.

# Declaration of Interests

The authors have no conflicts of interests to declare.

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