

ORIGINAL ARTICLE

Can virtuoso musicians teach surgeons how to cut? Self-regulated learning as a tool in surgical education: a thematic analysis of expert musician interviews

Hannah Winter^{a,b,*} and Jacqueline Rees-Lee^{a,c}

^aImperial College, London, St Mary's Medical School, Praed Street, Paddington, London, W2 1BY, UK; ^bBarts Health NHS Trust, West Smithfield, London, EC1A 7BE, UK; ^cTorbay and South Devon NHS Foundation Trust, Newton Road, Torquay, Devon, TQ2 7AA, UK

* Corresponding author at: Breast Unit, 1st Floor, West Wing, St Bartholomew's Hospital, London, EC11 7BE, UK. Email: hwinter@doctors.org.uk

Date accepted for publication: 19 September 2019

Abstract

Background: Observing musicians may offer illuminating parallels with surgical training, with several similarities between the two professions. Both utilize fine motor skills and are vocations, which involve in what can often be a stressful environment. As pressures on time within surgical training increase and learning opportunities decrease, understanding how to assist surgical trainees to reach the highest levels of achievement and become autonomous learners becomes increasingly important. Self-regulated learning (SRL) is a framework for lifelong learning used by musicians. It refers to self-generated ideas and thoughts that are planned and adapted to achieve personal goals. Within this dynamic framework adapted for medical education are four interacting cyclical processes: planning (goal setting); learning (learning styles and strategies); assessment (self-assessment alongside external feedback) and adjustment (self-evaluation and adaptation). SRL is not actively taught within surgical training but is fundamental to musicians. Therefore, this study sets out to identify approaches to SRL used by musicians to identify techniques that may be transferable to surgical training to assist surgical trainees in becoming independent learners and to maximize learning opportunities. **Methods:** Semi-structured interviews were performed with four expert cellists and data were analysed with six steps of thematic analysis. **Results:** Several themes emerged from the data that fell within the predefined phases of the SRL framework, including listening and strategy. The former highlighted the importance of critically listening to one's self, and to peers, teachers and critics. A pivotal master teacher was described by all as instrumental in the process of becoming independent learners. Two learning strategies were identified that may be transferable to surgical training: the use of video and audio recording analysis and the concept of instrument-free planning time, when the musicians spend time studying the musical score and planning bowings and fingerings before attempting to play. **Conclusion:** This study serves to generate ideas of how to integrate the teaching of SRL within surgical training to assist surgical trainees to reach higher levels of learning. Both learning strategies identified could be applied to surgical training, and indeed educators could be trained on how best to teach SRL amongst surgical trainees.

Keywords: Self-regulated learning; self-assessment; self-critique; simulation; surgical education

Background

Surgical training has faced many challenges and there is a clear need to identify methods to improve the quality of training within the current time restraints.^{1,2} Traditional surgical training is akin to an apprenticeship with observational learning, largely the observation of experts, and increasing operative experience and volume of cases. With a reduction in working hours and an increase in consultant-

led practice, learning opportunities for surgical trainees are increasingly precious.

Observational learning within surgical training has largely been centred around the observation of experts. Recent evidence suggests that observing novices with performances laden with error may be equally beneficial,³ increasing the importance of peer-based learning within surgical training in addition to expert observation. Alongside observational

learning, surgical simulation is becoming increasingly accessible. The emphasis on directing this learning and enriching the educational experience surrounding this is therefore increasing. Simulation provides an opportunity for surgical trainees to practice and refine skills, and complements traditional observational learning. What remains unclear is how to engage surgical trainees in higher cognitive skills, such as self-regulated learning (SRL), so that each of these learning experiences can be maximized and trainees can become more active participants in their own learning processes.

The concept of SRL has provided a greater understanding of successful learning within various disciplines and is considered by educationalists to be a sustainable framework for lifelong learning, consisting of a cyclical process related to personal characteristics, beliefs, attitudes, choices, judgments and actions.^{4,5} First proposed by Zimmerman in 2002, it has since been developed for use within medical education by White and Gruppen⁶ and described as four interacting cyclical processes: planning, learning, assessment and adjustment.

The planning process refers to the development of personalized educational goals and outcomes, which are identified by the learner and form the basis upon which they then self-assess their learning and performance. Self-efficacy and motivation are considered necessary for the identification of learning goals and subsequent commitment to achieving them.^{7,8}

Learning styles and strategies are techniques and methods of learning chosen by the individual with the learner demonstrating the ability and autonomy to exercise direct control over which strategy is applied. This requires a mature approach to the concept of learning and acquisition of knowledge.

The process of assessment refers to self-assessment, internal reflection and external feedback from peers and teachers. It requires personal and cognitive development to identify and address weaknesses and limitations. Accurate self-assessment is considered critical to the concept of self-regulated learning.⁹

Adjustment is the final process in this framework whereby the learner reflects on the entire process, analysing their achievements and identifying ways in which the learning strategies and approaches can be developed for future learning.

Self-regulated learning is of particular relevance within surgical training where knowledge is constantly evolving through medical research.¹⁰ There is a suggestion that

doctors may be inaccurate self-assessors,^{11–16} and that SRL is not actively taught as a learning strategy within medical education. Given the increasingly precious learning opportunities within surgical training, developing SRL techniques could maximize these opportunities and accelerate learning. It has been suggested that the ability to self-monitor is not an innate skill to learners, but more an approach that is taught and developed.¹⁷ The emphasis and drive therefore for many instructional systems is to encourage the development of self-monitoring in place of external feedback processes such that learners are in a position to adequately direct their own learning.¹⁸

The development of educational theories has arisen through the study of learning and development across numerous domains. The surgical profession has learnt from the aviation industry, with an emphasis on patient and passenger safety.¹⁹ Observing musicians, however, may offer illuminating parallels with surgical training, as suggested by Kneebone.²⁰ Several similarities exist between the two professions. Performing on a musical instrument requires relatively small, precise finger movements and bimanual coordination, as seen within surgery.^{20,21} Both involve performing in what can often be a stressful and critical environment associated with performance anxieties and relying on communication and teamwork with little margin for error. Both are competitive professions and require high levels of commitment and dedication. The most significant difference between the two is of course the patients and their safety. For this reason, surgeons are regulated and their practice and outcomes frequently reviewed. A musician is constantly seeking to learn and develop and does not have the service commitment required of surgical trainees. Musicians are also considered interpretative artists, whereas surgeons are not. Many would argue, however, that there is an artistry towards surgery that requires creativity and problem solving.²² In addition, expert musicians have usually started playing their instrument at a very early age and have the ability to practice independently away from the performance environment. Therefore, studying how musicians develop the ability to practice may be particularly useful to understanding how best to utilize surgical simulation, which similarly allows surgical trainees the opportunity for practice.

Self-regulated learning is fundamental to musicians, who are tutored with an emphasis on self-critiquing from early on in their development.²³ Differences between individual levels of engagement in the processes of SRL have been shown to appear early in musical training and these differences have been shown to have a significant role in the subsequent progress of individuals, suggesting these skills are key to success.²⁴

The lead author trained as a musician and used learning techniques acquired throughout musical training automatically during subsequent surgical training, providing a unique insight and basis for this study. This study aims to identify approaches to SRL applied by expert musicians and to explore how they develop the ability to accurately self-reflect and critique. With this knowledge, we hope to extrapolate techniques and approaches to SRL that are potentially transferrable to surgical training.

Methods

Study design and setting

Four expert cellists were identified and interviewed. Interviews were semi-structured and underpinned by the framework of SRL, exploring individual approaches to SRL.

Study recruitment

Expert cellists were identified using a combination of defined criteria to describe an expert (Table 1). Only British musicians were approached to improve cultural validity and reduce social and environmental influences; we used methods that had previously been adopted by others.^{25,26} Eligible cellists were approached by the interviewer (HW) either directly or through their agents and invited to participate in the study. No coercion was used. The concept of data saturation was used to determine when to end recruitment.

The interviews

The interviews were performed in a private setting convenient to the musicians. A semi-structured interview approach was used. Interview questions were piloted with colleagues and refined, resulting in five open-ended questions as outlined in Table 2. Interviews were audio recorded and transcribed for analysis.

Data analysis

Six steps of thematic analysis were performed: (1) familiarizing self with the data, (2) generating initial codes, (3) searching for themes, (4) reviewing themes, (5) defining and naming themes, (6) producing a report.

The coding process was initially performed by the lead author and subsequently reviewed by a second researcher (JR), ensuring consistency with interpretation. Any disagreement between the two authors was discussed until consensus was reached. Any unclear issues were clarified with the interviewees. The interviewing process was continued until data saturation, which occurred with four interviews.

The lead author (HW) is an experienced cellist and a surgical trainee. The second researcher (JR) is a consultant

Table 1. Inclusion criteria for expert musicians

Inclusion criteria	Basis for criteria
British cellist with > 10 years professional experience	The '10 year rule': 10 years of experience are considered necessary to become an expert ^{41,42,43}
Well regarded and respected with an international reputation	Previous authors have selected musical 'experts' based upon international reputation ⁴⁴
Regularly makes recordings with large record labels and is broadcast frequently on British radio stations	Lehman and Gruber suggested that an expert musician would work at making a lasting contribution towards the field of music by making sound recordings with major record labels, performing in prestigious concert venues and by achieving success in various competitions ⁴⁵
Performs regularly in prestigious venues	As above
Has performed in music festivals, including 'The Proms' or finalist / winner in competitions such as 'BBC Young Musician of the Year'	As above
Is at the forefront of their profession, as a soloist, chamber musician, or principal orchestral member in an internationally renowned orchestra	As above
Is primarily a performer, rather than teacher, but may teach alongside giving regular performances	Siedentop and Eldar suggested that expertise was performance related rather than teaching. ⁴⁶ With this in mind, musicians who primarily teach were excluded for the purposes of this study.

Table 2. Interview questions and relevant theoretical framework

Question	Rationale behind the question
Is there anything or anybody that you feel has helped influence you in your development with the cello?	To explore the role of external feedback in the process of SRL To explore the value of a master teacher ^{30,47}
How do you approach learning on your own?	Identify learning strategies and styles used by musicians that enable them to learn and develop alone
What motivates you to continue learning?	Motivation is key to the planning process in SRL. Exploring how and what motivates the musicians could help to identify ways to better engage surgical trainees in SRL
How do you approach a new or challenging piece of music?	Explore planning processes and learning strategies that could potentially be transferred to surgical training
Do you believe that ways to learn and think can be taught to students?	To potentially identify ways in which the development of SRL is / could be taught

surgeon, providing a range of insights into the interpretation and analysis of the data.

Ethical approval

A participant information sheet was designed alongside a consent form, and ethical approval was sought and supported from the Imperial College Head of Department and Joint Research Office. All participants gave written informed consent to participate.

Results

Four expert cellists were interviewed (musicians A–D). Several codes were identified throughout the data analysis and grouped together to form seven themes (Fig. 1). The themes included: understanding, motivation, learning from others, adjustment and experimentation, autonomy, listening and strategy.

Within the theme of understanding, the cellists identified the importance of their underlying level of knowledge and technical skill in their musical development.

I learnt how to play the cello, but at the end of the day it's not necessarily how you play a note in tune, it's how you make that note accessible to 2000 people who are listening to a concert; you have to use the knowledge that you've learnt (musician B).

The theme of motivation describes the passion and ambition behind these musicians who described music as a 'basic need'. They suggested that motivation requires encouragement and a supportive environment to ensure that the individual remains driven to continue learning and developing.

The theme of learning from others was named to encompass the influences that the musicians described throughout their career, in particular the importance of their teachers in helping them acquire not only knowledge and understanding, but a love and greater appreciation of the music and the ability to self-critique. The musicians each described a teacher who had encouraged them to think outside the box, challenging their thought processes. This theme also includes the influence from expert musicians, listening to recordings, watching live performances and attending master classes to see others taught or be taught themselves. The musicians also described the importance of peer critique and encouragement in their development.

Autonomy refers to the choice, responsibility, personal expectations, confidence and individual interpretation that musicians described throughout the interviews, highlighting the importance of the individual and their autonomy in the process of learning.

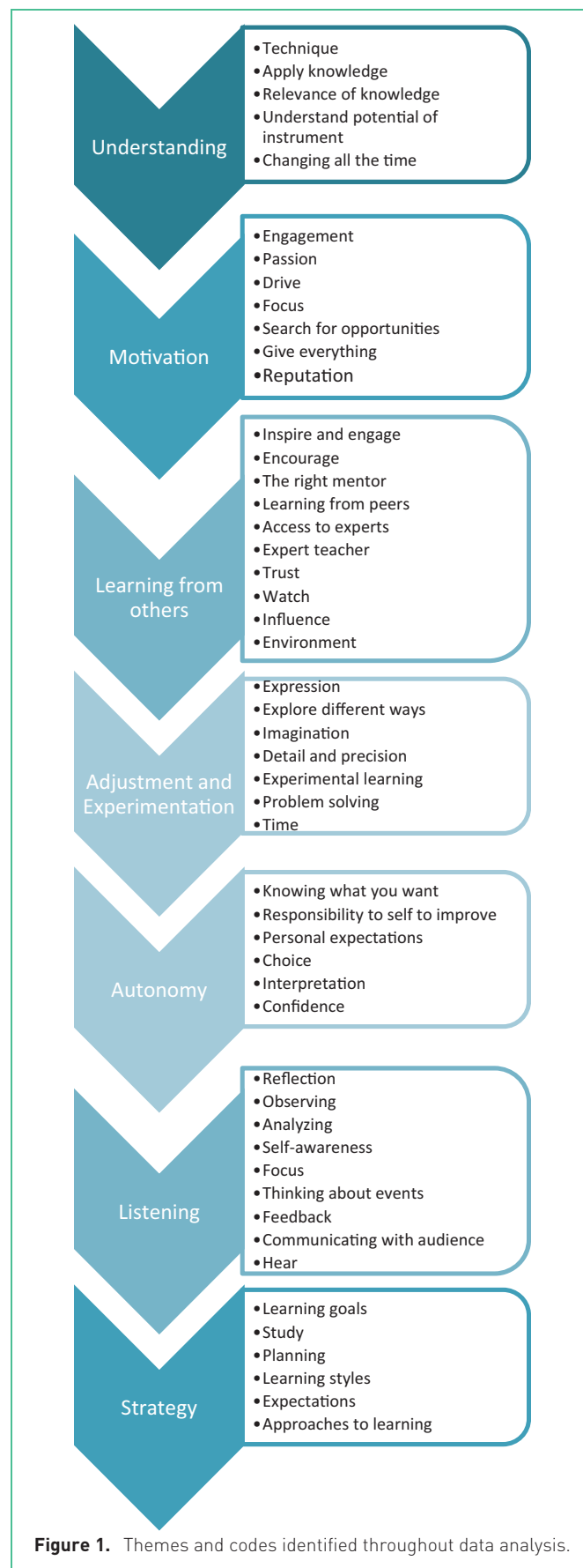


Figure 1. Themes and codes identified throughout data analysis.

Table 3. Musicians' quotes on the theme of listening

Listening in the beginning	There's so much of what we do that's learnt through listening (musician B) Practicing ... is not masses of repetition, it's research, you start your practicing like you enter your research lab and you're looking for something ... a way of understanding the music (musician A) Often when children practice ... they're not really looking, they're not really concentrating and so they miss those opportunities (musician A) To do that, you have to build up a lot of knowledge and skill about how the instrument works (musician A)
Listening to experts	You have to listen to great playing (musician A) It's all sorts of things that you pick up along the way, whether you know it or not. So you hear someone's sound, you want to find that in your own playing ... or you like someone's interpretation (musician C)
Listening to peers	If someone's playing either not that well or much better than you, you're going to want to do something about it if you're to present a performance so we were criticising each other in small groups (musician D) I admire everyone, all the musicians I hear, their playing in some way, whatever it is about them (musician C)
Listening to critique	It can knock you a lot, but it does do you some good as well, having that negative energy, because it makes you listen more deeply (musician C) It makes you re-focus and listen more intently (musician D)
The role of the teacher in learning to listen	Initially... it was a basic question ... what strings make what noise, learning the different clefs that you need to use, learning where to put your fingers on the fingerboard, just nuts and bolts technical training so that you become more comfortable with playing lots of different notes on the cello and then the second teacher was sort of opening up the doors of 'yeah sure you can play the first movement of the Elgar concerto very well and in tune, but do you really know what's behind the notes and have you thought about playing it this way or that way or the other way? or what does it actually mean?' ... giving me the idea that there are many, many options available to me and that it's not just playing the notes (musician D) Somewhere, something ... completely changed my taste in music and performance and turned it upside down in what I looked for in music (musician A). She completely deepened my understanding ... and I realized that music is far more than that which I hadn't realized before despite being quite musical and from a very musical family. It just made it deeper and that was the main, primary thing (musician A) One of the teachers was really adamant that I should start teaching myself, as in teaching other students. So he would pass on people to me and I realized then that the reason he did that was to make me think for myself and for that student, then to start to interpret everything that I'd been taught (musician C)
Listen to themselves	You've got to be very alert to 'something on some note sounds really fine'. How does that happen? And why not on other notes? You find that you're doing something because of the position of the fingers on that particular note which is just right and then that can become your teaching and you can transfer it to other notes (musician A) I know more and more my strengths and weaknesses and am working at those weaknesses all the time (musician C) My taste has been influenced by a lot of different performers and musicians, but I feel more and more I understand who I am and what I want to express and develop (musician C)

Listening (Table 3) and strategy (Table 4) are described in more detail below.

Listening

Listening in the beginning

The musicians described their experiences when young, stating that they were unable to practice their instruments effectively, believing that merely repetition would suffice. At that stage in their development, they expected to be 'spoon fed' (musician B) information from their teachers and shown what and how to develop. This was described by one cellist as an 'infantile approach to learning' (musician A).

Through developing the ability to really hear themselves playing, they became better engaged in the process of individual practice and in identifying opportunities for further development. They also identified that when young, their underlying knowledge of the instrument was limited and as such they had less understanding of what they were listening for and aiming towards.

Listening to experts

The musicians spoke passionately of inspirational figures they had met, listened to or watched throughout their early development that had helped to 'raise [their] awareness of what is possible with a musical instrument' (musician A). This exposure helped them to look more closely at their own playing, to listen to themselves in greater depth and identify different ways of playing. This was also considered motivational, encouraging them to develop their practice techniques.

In describing the feeling of hearing an expert play a great piece of music, a musician suggested

it leaves you feeling that you've been much more engaged in all parts of it. In a way it changes your life to hear a great performance of a great piece of music (musician A).

Listening to peers

Peer encouragement and involvement was suggested by all the musicians as important for developing their ability to listen to themselves through listening to and critiquing others. In performing within chamber ensembles, they

Table 4. Musicians' quotes on the theme of strategy

Private instrument-free study	I used to pick up my cello and sort of start playing it, reading the notes, then chip away and refine what I'm playing, but I didn't really start with any conception. So of course I was practicing all sorts of habits and as soon as you put the bow on the string, you're choosing a colour and a bow speed and a way of shaping the phrase and so on, but actually you're not really choosing when you start sight-reading a piece because you don't know what you're doing. Now I much prefer to have a long long time just looking at the score and looking at it (musician A) I try things and phrase it in my head and think about it and try to make a construction out of it, deciding what the piece is about and what the story is telling ... so that when you start putting [the bow] on the instrument you know what you're aiming for (musician A) I'll try and map out what's needed in the piece ... looking at the difficult bits, looking at the overall shape, seeing what kind of plan the piece has ... and technical content (musician D) You've got to listen to great playing, get recordings out and try and look at how other people approached it and yet you always have your own stamp on the piece (musician B)
Listening and watching recordings of performances and practices	Very very powerful wake up call (musician C) What you can do as a musician, if your performance is recorded, you can go back and listen to it, or particularly if it's on the television, you can go back and have a look ... that's the quickest teacher of them all (musician D) As opposed to expressing through me and out, I want to imagine I'm now listening and then I can respond the other way (musician C) I could see physical things that weren't quite working ... I just saw the way I looked and I thought – that doesn't seem right, I'll change that (musician D) I think it's such a powerful tool that it should be used quite sparingly ... with everything like that you can get a bit blasé about it (musician D) There's no interpretation involved ... you can't argue with it. You did this and you can say I don't think I did ... yet you can see it, the physical movement that you made and you can hear the audio and whether it worked (musician C) It's really hard to listen back to yourself because it's like all the warts and everything else that you don't want to hear but you have to accept and it's something that you then go away and you work at (musician C) [He] knew what to look for and would pause the video and say 'what happened there? Why did that go wrong?' (musician D)

each have a responsibility to ensure the overall sound is good and as such, a responsibility to each other to ensure they play together and with the same goals and interpretations of the music.

Listening to critique

As experts, they are subject to open critique from peers and the press. Their constructive response to negative feedback is evident as they recognize the importance of going back on a performance and interrogating it to understand the comments and learn from them.

The role of the teacher in learning to listen

The influence of their teachers in helping them gain the ability to listen was clearly evident. Indeed, all the musicians identified a teacher who they felt had been particularly influential in taking their learning to a new level. Where earlier teachers had helped them develop a basic knowledge of their instrument, technique and music in general, subsequent teachers were able to take this further and challenge the way in which they listened and thought, encouraging a more creative attitude.

These very inspiring teachers seemed to also change the musicians' taste in music, and therefore what they were looking for in their own playing. This teaching encouraged them towards a practice method that was more inquisitive and self-directed.

Learning to listen to themselves

Eventually, with the above influences and with increasing experience and mentoring, the musicians developed the

ability to listen, self-critique, and guide their practice sessions accordingly.

Strategy

The musicians described various strategies that they continue to use to develop their ability to practice, to engage in listening, to approach a difficult piece and subsequently to develop their understanding of the music and skills as musicians.

You really have to go deeply into the music and understand much more what it is about (musician A).

Private instrument-free study

When they started out, they explained that they used to take a new piece of music and start playing, sight reading it, experimenting and gradually refining. However, as they have become more experienced, this has changed, the criticism of this being the lack of planning and the risk therefore of the interpretation of the music being lost. Instead, they now begin by studying the music score in depth before touching their instrument. With this approach, they can consider the phrasing and overall shape of the music such that when they begin to play, they have an idea of how they want it to sound. In addition, they can identify potential pitfalls and highlight areas for potential struggle such that approaches to these sections can be considered beforehand. When playing in groups, or performing a concerto with an orchestra, not only do they study their part but also the parts of the other musicians. By doing so, they can understand how the individual parts come together and gain a deeper understanding of the music. Alongside studying the

music score, they also listen to other peoples' recordings of the music so that they can generate ideas for interpretation and consider how they may wish to approach the piece.

Listening and watching recordings of performances and practices

The musicians frequently listen back to themselves, using both audio and video recordings. Through doing so they are able to hear themselves from a different perspective, seeing and hearing what others do. This was deemed useful, not only to listen to phrasing and musical interpretation but also to view posture or technique that could be improved. To maximise the learning achieved through analysing a recording, the musicians recognized the importance of a teacher or mentor to guide them. One musician described a course he had attended in which he and his peers were recorded performing, and subsequently, in the presence of the peers and mentor, the recordings were 'picked over and analysed' in turn.

That may have only been 7 or 8 days' worth of teaching but it just sorts things out incredibly quickly (musician D).

The musicians identified that this experience is uncomfortable and unpleasant, but it is a strategy that has assisted in their ability to listen to themselves and become more self-aware. It was considered by the musicians as an accurate portrayal of the individual and thus a reliable source from which to assess one's performance.

Discussion

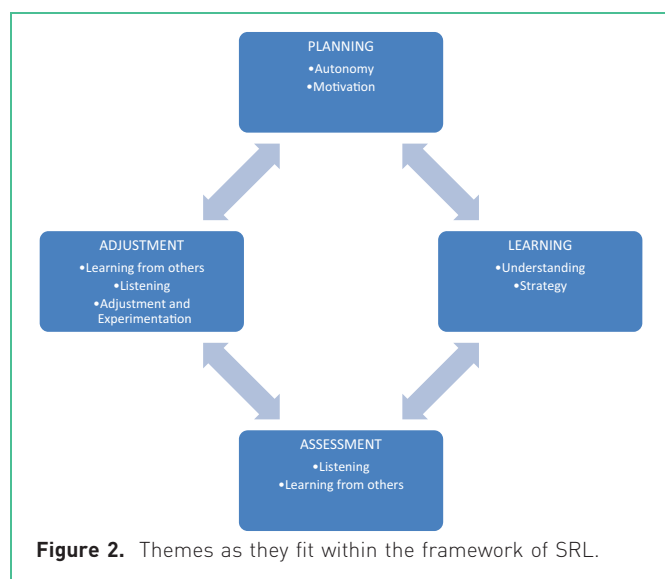
Surgical training has seen many changes in the last 20 years. Pressures on time within surgical training has increased, and learning opportunities and numbers of operating cases logged among surgical trainees have decreased.²⁷ The Royal College of Surgeons, recognizing the issues within surgical training, are piloting a new training programme, Improving Surgical Training. Alongside changes to service commitments, this has addressed the importance of individualized training, removing the statutory time required for completion of training and encouraging a competency-based approach. Simulation is to be embedded within this training programme, and therefore understanding how to assist surgical trainees to self-regulate their learning and become autonomous learners becomes increasingly relevant.

The greatest similarity between musicians and surgeons is the acquisition of a practical skill. The ability to partake in sustained deliberate practice amongst musicians is instrumental to their success and is sadly not available to surgical trainees on as regular a basis. Surgical trainees have a

balance between learning and service commitment; the latter takes priority over individual learning for the benefit and safety of patients, as identified within a study reviewing surgical educators' views on SRL amongst surgical trainees.²⁸ However, with increasing exposure to simulation, the time for practicing their skill may become more of a reality for surgical trainees.

This study sought to identify how expert musicians had developed the ability to self-regulate their learning and did so through semi-structured interviews, allowing the musicians to speak freely of their experiences. In analysing each of the interviews, seven themes arose, and each of these can be seen to fit within the previously described phases of SRL (Fig. 2). Motivation and autonomy are features of the initial process of SRL, planning; i.e. having the confidence and desire to identify goals and strive to achieve them. Understanding and strategy are features of learning, identifying the need for an underlying knowledge base, a respect and understanding of the potential of their instrument, and the identification of learning styles and strategies to suit each learning goal. Listening and learning from others fall within the process of assessment, whereby the musicians recognized the importance of listening to themselves and to others, learning to self-assess and to digest external feedback. Lastly, learning from others and listening also come within the adjustment process alongside adjustment and experimentation, where the musicians reflect on their performance and identify ways to improve both their performance and learning.

SRL has been described as developing through interactions between the person, their behaviours and the environment.²⁹ The environment within music is somewhat easier to change compared with surgical training. It can also be said that learning to work within changing environments is helpful to surgical trainees as they learn to adapt to different situations within the National Health System. As identified in the survey of surgical educators, surgical trainees have limited control over who their trainers are and what their learning goals may be.²⁸ The musicians, however, ascribed great importance to their teacher and had the ability to choose the teacher to suit them. The concept of the master teacher was described by Zuckerman, who identified that experts sought out specific teachers who performed a role similar to that described by the musicians.³⁰ The teachers helped the musicians to see beyond simply playing the cello and encouraged creativity and an inquisitive approach. This enabled them to find in music what they had not yet seen and introduced them to a new world of self-evaluation and continual development. We recognize that surgical trainees have limited choice of trainers and that most medical



educators have not had formal training in how to teach SRL.³¹ However, we hope that this study encourages the reader to consider that if surgical trainers can be educated about the role of SRL within surgical training and how to teach SRL skills, this could have a significant impact on the learning experience of surgical trainees.

In addition to their teachers, the musicians placed equal importance on learning with their peers, critiquing one another and working together. Master classes were mentioned as an opportunity to be taught in front of peers, or to watch another student be taught and were described as a useful learning experience. One described a course where recordings of performances were reviewed and the students collectively critiqued one another. At undergraduate level within medicine, problem-based learning is regularly taught in small groups with the aim of improving student-directed learning.³² Once embedded within a surgical training programme, however, peer group learning opportunities are sadly scarce despite evidence demonstrating the benefits.³

Strategy, one of the themes to emerge from this study, encompassed two main tools that the musicians used to aid learning and development: private instrument-free planning and video/audio recording analysis. Similarly, a framework for SRL within surgery has been developed and encompasses seven themes, one of which is strategic planning, where the trainee undertakes self-preparation.²⁸

Professor Stephen Westaby, an expert cardiac surgeon, described in his book *Fragile Lives* how he drew pictures of complex surgeries beforehand to plan the operations.³³

Encouraging trainees to do this and mentally rehearse the steps of an operation when scrubbing up may address this in part. A further proposal is to consider teaching operations in sections, slowly building up the separate parts of an operation to concentrate on the detail within each component before attempting skin to skin.

The second strategy, recording and self-critiquing one's performance, has been previously described within music as a technique used to assist the learner to self-monitor.³⁴ The musicians within this study did this in several formats: alone, with their teacher and among their peer groups in a structured and controlled setting. Within other research, this process has been shown to engage students in making judgements about their own performances³⁵ and encourages reflection of learning processes.³⁶ Video review has also been shown to be an effective tool in disciplines other than music, such as sports.^{37,38} It provides an opportunity for targeted feedback in a less stressful environment. Within surgery, it has been shown to be beneficial in both simulated³⁹ and real-life settings,⁴⁰ but evidence is limited and it is not yet common practice. We recognize that reviewing recordings is labour intensive and time consuming in an already time-pressured health system, but this strategy could be a valuable tool in the surgical setting to assist trainees in developing SRL. Using video recordings of simulated operations in peer group assessment courses, similar to the musical equivalent described in this study, could be explored and may fulfil two further themes: self-awareness and progress evaluation, identified in the framework of SRL among surgical trainees alongside strategic planning described earlier.²⁸

This study included only a small number of musicians. It does, however, demonstrate a clear need for further evaluation into the potential parallels between music and surgery and validates musicians as a rich source of information with regards to SRL concepts and ideas.

The aim of this study is to generate thought and ideas on how to extrapolate methods of teaching and developing SRL among surgical trainees. We acknowledge the differences between music and surgery and in particular, recognize the patient at the centre within surgical training, but highlight also the numerous similarities and parallels between musical and surgical training. This study has confirmed the importance of SRL in developing successful learning amongst expert cellists. The two themes of listening and strategy have highlighted important and potentially transferable techniques used by musicians to develop the ability to self-regulate learning. Extrapolating these techniques to surgical training may assist surgical trainees to become independent lifelong learners.

Conflict of interest

None declared.

References

- Giles J. Surgical training and the European Working Time Directive: the role of informal workplace learning. *Int J Surg* 2010; 8: 179–180. <https://doi.org/10.1016/j.ijssu.2010.01.011>.
- Ludmerer K. Time to heal: American medical education from the turn of the century to the era of managed care. New York, Oxford University Press; 1999.
- Harris DJ, Vine SJ, Wilson MR, McGrath JS, LeBel M, Buckingham J. The effect of observing novice and expert performance on acquisition of surgical skills on a robotic platform. *PLoS One* 2017; 12. <https://doi.org/10.1371/journal.pone.0188233>.
- Zimmerman B. A social cognitive view of self-regulated learning. *J Educ Psychol* 1989; 81: 329–339. <https://doi.org/10.1037/0022-0663.81.3.329>.
- Zimmerman BJ. Becoming a self-regulated learner: an overview. *Theory Pract* 2002; 41: 64–70. https://doi.org/10.1207/s15430421tip4102_2.
- White C, Gruppen L. Self-regulated learning in medical education. In: Swanwick T, editor. *Understanding medical education*. Edinburgh: Association for the Study of Medical Education; 2007. p. 201–211.
- Bandura A. Self-efficacy. In: VS Ramachandran, editor. *Encyclopedia of human behavior*, vol. 4. New York: Academic Press; 1994. p. 71–81.
- Locke E, Latham G. A theory of goal setting and task performance. Englewood Cliffs, NJ: Prentice Hall; 1990.
- Treffinger DJ. Teaching for self directed learning: a priority for the gifted and talented. *Gifted Child Q* 1975; 19: 46–59. <https://doi.org/10.1177/001698627501900109>.
- Hoban J, Lawson S, Mazmanian P, Best A, Seibel H. The self-directed learning readiness scale: a factor analysis study. *Med Educ* 2005; 39: 370–379. <https://doi.org/10.1111/j.1365-2929.2005.02140.x>.
- Eva K, Regehr G. Self-assessment in the health professions: a reformulation and research agenda. *Acad Med* 2005; 80: S46–S54. <https://doi.org/10.1097/00001888-200510001-00015>.
- Davis D, Mazmanian PE, Fordis M, Van Harrison R, Thorpe KE, Perrier L. Accuracy of physician self-assessment compared with observed measures of competence. *JAMA* 2006; 296: 1094–1103. <https://doi.org/10.1001/jama.296.9.1094>.
- Sidhu R, Vikis E, Cheifetz R, Phang T. Self-assessment during a 2-day laparoscopic colectomy course: can surgeons judge how well they are learning new skills? *Am J Surg* 2006; 191: 677–681. <https://doi.org/10.1016/j.amjsurg.2006.01.041>.
- Ward M, MacRae H, Schlachta C, Mamazza J, Poulin E, Reznick R, et al. Resident self-assessment of operative performance. *Am J Surg* 2003; 185: 521–524. [https://doi.org/10.1016/S0002-9610\(03\)00069-2](https://doi.org/10.1016/S0002-9610(03)00069-2).
- Tousignant M, DesMarchais J. Accuracy of student self-assessment ability compared to their own performance in a problem-based learning medical program: a correlation study. *Adv Health Sci Educ* 2002; 7: 19–27. <https://doi.org/10.1023/A:1014516206120>.
- Rezler A. Self-assessment in problem-based groups. *Med Teach* 1989; 11: 151–156. <https://doi.org/10.3109/01421598909146318>.
- Baker L. Children's effective use of multiple standards for evaluating their comprehension. *J Educ Psychol* 1984; 76: 588–597. <https://doi.org/10.1037/0022-0663.76.4.588>.
- Sadler D. Formative assessment and the design of instructional systems. *Instruct Sci* 1989; 18: 119–144. <https://doi.org/10.1007/BF00117714>.
- Catchpole K, De Level MR, McEwan A, Pigott N, Elliott MJ, McQuillan A, et al. Patient handover from surgery to intensive care: using Formula 1 pit-stop and aviation models to improve safety and quality. *Paediatr Anaesth* 2007; 17: 470–478. <https://doi.org/10.1111/j.1460-9592.2006.02239.x>.
- Kneebone R. Practice, rehearsal, and performance. An approach for simulation-based surgical and procedure training. *JAMA* 2009; 302: 1336–1338. <https://doi.org/10.1001/jama.2009.1392>.
- Watson A. What can studying musicians tell us about motor control of the hand? *J Anat* 2006; 208: 527–542. <https://doi.org/10.1111/j.1469-7580.2006.00545.x>.
- Prado A, Andrades P. Creativity in plastic surgery. *Aesthet Plast Surg* 2008; 32: 409–410. <https://doi.org/10.1007/s00266-008-9137-7>.
- Hallam S. The development of metacognition in musicians: Implications for education. *Br J Music Educ* 2001; 18: 27–39. <https://doi.org/10.1017/S0265051701000122>.
- McPherson GE, Zimmerman BJ. Self-regulation of musical learning: a social cognitive perspective on developing performance skills. In: R Webster, PR Colwell, editors. *MENC handbook of research on music learning*, vol. 2: Applications. New York: Oxford University Press; 2011. <https://doi.org/10.1093/acprof:osobl/9780199754397.003.0004>.
- Bloom B. *Developing talent in young people*. New York: Ballantine; 1985.
- Solano-Flores G, Nelson-Barber S. On the cultural validity of science assessments. *J Res Sci Teach* 2001; 38: 553–573. <https://doi.org/10.1002/tea.1018>.
- Thomas RL, Karanjia N. Comparison of SHO surgical log-books a generation apart. *Ann R Coll Surg Engl* 2009; 91 (Suppl): 356–359. <https://doi.org/10.1308/147363509X475781>.
- Johnson CE, Yates K, Sullivan M. Building a framework for self-regulated learning in surgical education: a Delphi consensus among experts in surgical education. *J Surg Educ* 2019; 76 (6): e56–e65. <https://doi.org/10.1016/j.jsurg.2019.06.012>.

29. Bandura A. Social foundations of thought and action. A social cognitive theory. Englewood Cliffs, NJ: Prentice Hall; 1986.
30. Zuckerman H. Scientific elite: Nobel laureates in the United States. New Brunswick: Transaction Publishers; 1977.
31. Reynolds AK. Academic coaching for learners in medical education: twelve tips for the learning specialist. *Med Teach* 2019; 7: 16. <https://doi.org/10.1080/0142159X.2019.1607271>.
32. Wood D. Problem based learning. *BMJ* 2003; 326: 328. <https://doi.org/10.1136/bmj.326.7384.328>.
33. Westaby S. Fragile lives. London: Harper Collins; 2017.
34. Lebler D. Student-as-master? Reflections on a learning innovation in popular music pedagogy. *Int J Music Educ* 2007; 25: 205–221. <https://doi.org/10.1177/0255761407083575>.
35. Somervell H. Issues in assessment, enterprise and higher education: the case for self-, peer and collaborative assessment. *Assess Eval Higher Educ* 1993; 18: 221–233. <https://doi.org/10.1080/0260293930180306>.
36. Boud D, Falchikov N. Quantitative studies of self-assessment in higher education: a critical analysis of findings. *Higher Educ* 1989; 18: 529–549. <https://doi.org/10.1007/BF00138746>.
37. Franks I, Nagelkerke P. The use of computer interactive video in sport analysis. *Ergonomics* 1988; 31: 1593–1603. <https://doi.org/10.1080/00140138808966809>.
38. Liebermann DG, Katz L, Hughes MD, Barlett RM, McClements J, Franks IM. Advances in the application of information technology to sport performance. *J Sports Sci* 2002; 20: 755–769. <https://doi.org/10.1080/026404102320675611>.
39. Jamshidi R, LaMasters T, Eisenberg D, Duh QY, Curet M. Video self-assessment augments development of videoscopic suturing skill. *J Am Coll Surg* 2009; 209: 622–625. <https://doi.org/10.1016/j.jamcollsurg.2009.07.024>.
40. Herrera-Almario G, Kirk K, Guerrero VT, Jeong K, Kim S, Hamad GG. The effect of video review of resident laparoscopic surgical skills measured by self- and external assessment. *Am J Surg* 2016; 211: 315–320. <https://doi.org/10.1016/j.amjsurg.2015.05.039>.
41. Ericsson KA, Crutcher RJ. The nature of exceptional performance. In: Baltes PB, Featherman DL, Learner RM, editors. *Life-span development and behaviour*, vol. 10. Hillsdale, NJ: Erlbaum; 1990. p. 182–217.
42. Simon H, Chase W. Skill in chess. *Am Sci* 1973; 61: 394–403.
43. Hayes J. The complete problem solver. Philadelphia, PA: Franklin Institute Press; 1981.
44. Repp B. Expressive timing in a Debussy prelude: a comparison of student and expert pianists. *Music Sci* 1997; 1: 257–268. <https://doi.org/10.1177/102986499700100206>.
45. Lehman AC, Gruber H. Music. In: KA Ericsson, N Charness, PJ Feltovitch, RR Hoffman, editors. *The Cambridge handbook of expertise and expert performance*. Cambridge: Cambridge University Press; 2006. p. 457–470. <https://doi.org/10.1017/CBO9780511816796.026>.
46. Siedentop D, Eldar E. Expertise, experience and effectiveness. *J Teach Phys Educ* 1989; 8: 254–260. <https://doi.org/10.1123/jtpe.8.3.254>.
47. Roe A. The making of a scientist. New York: Dodd, Mead & Company; 1952.