ORIGINAL REPORTS

Digital Training Resources in the Dutch Surgical Residency Curricula and the Perspectives of Residents: A Thematic Analysis of Resident Interviews

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BACKGROUND: Digital training resources show great promise in augmenting traditional surgical education – especially in times of social distancing and limited surgical caseload. Embedding digital resources in surgical curricula is however not current, nor common practice in Dutch hospitals. While the digital world has become part of a resident's everyday life, surprisingly little is known about surgical residents' experiences and expectations towards use of digital resources for their own surgical education. This study aims to identify digital resources currently used in Dutch surgical curricula and to describe surgical residents' perspectives towards digital education.

METHODS: A series of semi-structured interviews with Dutch surgical residents were conducted until data sufficiency occurred. The interviews consisted of two parts: 1) current surgical training and implemented digital resources, and 2) future surgical training and the role of digital resources therein. All interviews were digitally recorded, transcribed verbatim, and thematically analyzed.

RESULTS: Sixteen surgical residents were interviewed – two out of each of the eight educational regions for surgery in the Netherlands. Five digital resource categories were identified and four general educational themes (requirements, advantages, disadvantages, and general education themes), overarching 13 sub-themes. In general, residents were enthusiastic with regard to using digital resources, especially when the perceived advantages supported their autonomy.

CONCLUSIONS: Dutch surgical residents indicate that digital resources may support their educational experiences, but state that ideally they must be combined with much appreciated on-the-job training, and be offered to them tailored to their individual needs. No resources are considered to be a "magic bullet" in itself. The specific needs of residents and educators need to be addressed clearly in order to successfully adopt and implement digital resources on a larger scale. (J Surg Ed 000:1–11. © 2022 The Author(s). Published by Elsevier Inc. on behalf of Association of Program Directors in Surgery. This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/4.0/))

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INTRODUCTION

Surgical residency programs are facing many challenges today. One of them is providing residents with sufficient exposure to clinical experiences – including high-level supervised hands-on training in the operating room.[1] This proved and proves to be a challenge – to say the least – in the COVID-19 pandemic, when downscaled elective surgery, relocation of residents to COVID-19 units, and social distancing regulations, prevent(ed) surgical residents from having proficient hands-on experience.[2–5]

Digital training is here defined as by the European Commission definition: The pedagogical use of digital technologies to support and enhance learning, teaching and assessment. This includes resources such as Virtual Reality (VR), digital box trainers, and mobile application, which seem promising as they can mimic clinical practice. Using these tools, residents can practice and make any mistakes without the risk of harming patients.[6–8] Moreover, residents can be exposed to cases which are uncommon, train specifically needed knowledge and skills, and access these resources on demand – all of which is not the case for clinical practice, and only partly the case for wet- and dry-lab training. However, embedding digital resources in surgical curricula is neither current nor common practice in Dutch training hospitals. There is no clear overview of available digital resources specifically for surgery and including information on their contents, their quality, and on the perspectives of residents towards these resources. Consequently, successes and failures of using and implementing digital resources are not easily shared, and successful initiatives that might be beneficial to others remain under the radar. Plus, there is no opportunity to learn from challenging situations elsewhere. This may result in "reinventing the wheel" situations for training at best, and waste of time, effort, knowledge and resources at worst. Moreover, while knowledge about the experiences and expectations of surgical residents towards use of digital resources for their own education is essential, surprisingly little is known on the subject. Therefore, this study aims to 1) identify digital resources currently in use in Dutch surgical residency programs and 2) assess the perspectives of surgical residents with regards to these resources.

MATERIALS AND METHODS

Study Design

An explorative qualitative study was designed in which semi-structured interviews with Dutch surgical residents were conducted and analyzed using an inductive thematic approach.[9] This approach ensured that several pre-determined concepts were discussed, and provided freedom to explore the experiences and vision of each individual participant. Because this approach implies that outcomes are actively constructed by and between participants and researchers, the constructivist paradigm was followed.[10] To that regard information on the authors is relevant for our readers: all authors are medical doctors, educators and educational researchers affiliated with Amsterdam UMC. TF coordinated the study and conducted the interviews as part of a PhD-project, ENvD and MS are both principal investigators and principal educators within the surgery department, ENvD is president of the regional surgical residency program and supervised this project, and MM is an expert on qualitative research, especially with regard to health professions education.

The study was performed in accordance with the Standards for Reporting Qualitative Research (SRQR) guidelines.[11] The institutional review board (IRB) waved the need for an official IRB review because participants were healthy, not subject to any intervention other than the interviews, participated voluntarily, and all data was used and stored anonymously.

Setting and Participants

The Dutch surgical residency program is divided in eight educational regions, each containing multiple training hospitals and a University Medical Center (UMC). Dutch residents follow six years of surgical training, alternating attending a teaching-governing UMC and affiliated teaching hospitals. The first four years or residency are called the "common trunk": In these years the residents focus on acquiring, and becoming proficient in fundamental surgical skills and competencies. In the two final years, the so-called "differentiation phase", residents focus on their preferred specialization: Gastro-intestinal surgery, surgical oncology, trauma surgery, vascular surgery, or pediatric surgery.

All Dutch surgical residents were considered eligible for participation in our study. Residents were approached to collaborate using existing national resident networks such as the surgical resident society and regional network groups. No compensation was offered for participation. Criterion-based stratified purposeful sampling was used to ensure a balanced distribution of educational regions, sex, and surgical experience.

Interview Guide

The interview guide (Supplementaryfile I) was developed by discussing the aims among the research team, and refined during the interviews through a process of constant comparison. This technique involves improving the original interview guide based on newly identified themes and concepts in subsequent interviews,

thereby providing flexibility in identifying and exploring new topics during the interview process.

Following the aims of this study, the interviews were split into two parts. The first part was aimed at canvassing residents' experiences of current surgical training and identifying digital resources currently in use. In the second part, residents were asked to specify their vision on the future of surgical training and the residency, and the role of digital resources therein. This part included the question "If you could construct a teaching curriculum according to your own preferences, what would that look like?" – which aimed to concretize participants' vision on the implementation and place of digital resources in the curricula.

Interview Procedures

Residents who responded to the invitation were invited for an interview with Trial Master File (TMF), which took place between April and August 2020. The first interviews were conducted face-to-face at the hospital site of the participant, while later interviews were conducted via video-conferencing. This, due to COVID-19-related restrictions of hospital access. Each interview was audio and/or video-recorded with explicit permission of the participant, transcribed verbatim after interview completion, and analyzed directly to allow for constant comparison. The transcribed interviews were available for participants to review, to provide feedback or to further elaborate on answers given. Interviews were conducted until data sufficiency was achieved. Data sufficiency suggests that the data is "good enough" for the breadth of the research questions and that the sample size is large enough to allow transferability of concepts to other contexts.[12,13] This, as opposed to data saturation which suggests that the extracted data is objectively "exhaustive" – a feature which is hard to prove.[12,13] All transcripts were de-identified, stored, organized and analyzed using MAXQDA 2020 (VERBI Software GmbH, 2019).[14]

Qualitative Analysis

The two parts of the interview guide served as an initial guide for thematic analysis of the interviews, following the methodology proposed by Braun & Clarke in 2006.[9] TF and ENvD independently analyzed each interview and used the inductive thematic approach to identify relevant themes. Preliminary open coding of a data subset yielded an initial coding template, which was applied to further data, and modified if necessary. Disagreements in coding were resolved by consulting a third reviewer if necessary (MS). After codebook finalization, patterns between the codes were identified to establish the final thematic framework.

RESULTS

Participant Characteristics

Data sufficiency occurred after completion of 16 consecutive interviews. The age of participants ranged from 28 to 35 years and men and women were included equally. Fourteen residents were in the common trunk part of residency (eight in years 1-2, six in years 3-4), and two residents were in their differentiation phase. The duration of the interviews varied between 25 and 50 minutes, and the first three interviews (18%) were conducted in person. Two residents who showed initial interest in participation did not react to the subsequent invitation and were therefore excluded from the study and analysis.

Thematic Framework

Five categories of digital resources were identified (Fig. 1), and residents were generally open and enthusiastic to the use of any of these resources, regardless of previous use the resource. *Background information databases* were the most used resources, and consisted of traditional resources such as guidelines, anatomy atlases, and surgical skills atlases which were converted to a digital format. *Knowledge-sharing environments* comprise a wide array of resources which can be used to transfer knowledge by solely listening or viewing. An -often mentioned- example were the surgical livestreams on training models which were securely broadcasted by the Dutch Surgical Association during 2020. *E-learnings* consist of an online learning environment to transfer knowledge and/or skills. Unlike knowledge sharing environments, a form of interaction and self-tests are usually part of the learning experience, and e-learnings can be "made" when and where is convenient or necessary. These learning methods are usually constructed locally, or part of a course or training module. *Serious games* are resources which support learning by providing learning or practicing in a playful matter. Examples are a candy-crush type of game to recognize problems occurring during laparoscopic surgery, and a game on the Nintendo Wii which aims to train hand movements necessary during laparoscopic surgery. Lastly, *(digital) skills trainers*, are tools which provide skills training opportunities outside the clinic. Examples are box-trainers and Virtual Reality (VR)-trainers, both of which allow residents to practice skills and make mistakes without harming patients.

Three themes on digital resources and education in general were retrieved, overarching 13 sub-themes. Figure 2 depicts these (sub-)themes and how the digital themes interact with the general education themes

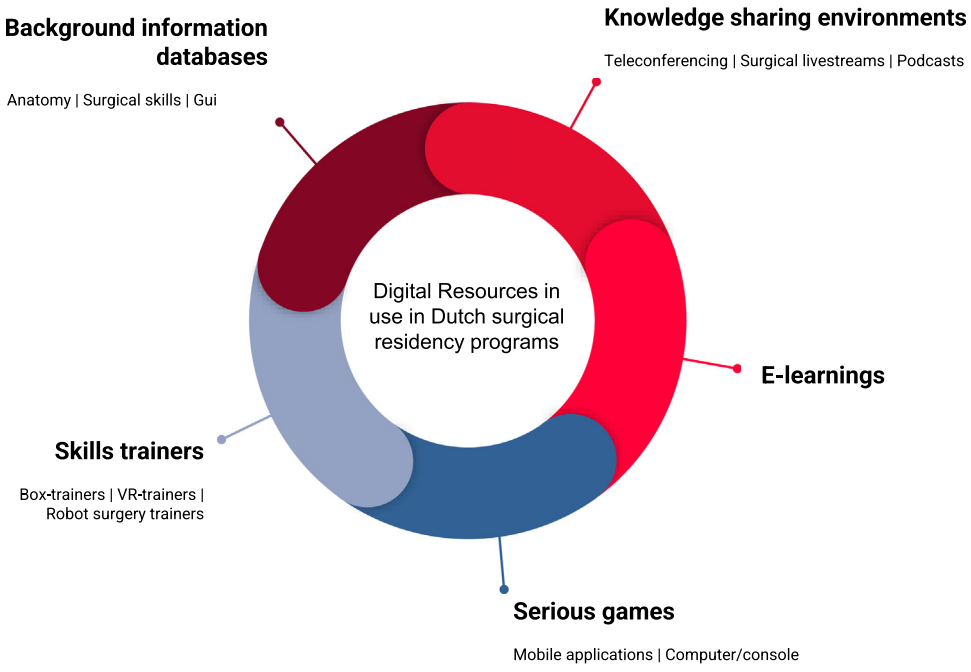

FIGURE1. Overview of digital resources currently in use in Dutch surgical residency programs.

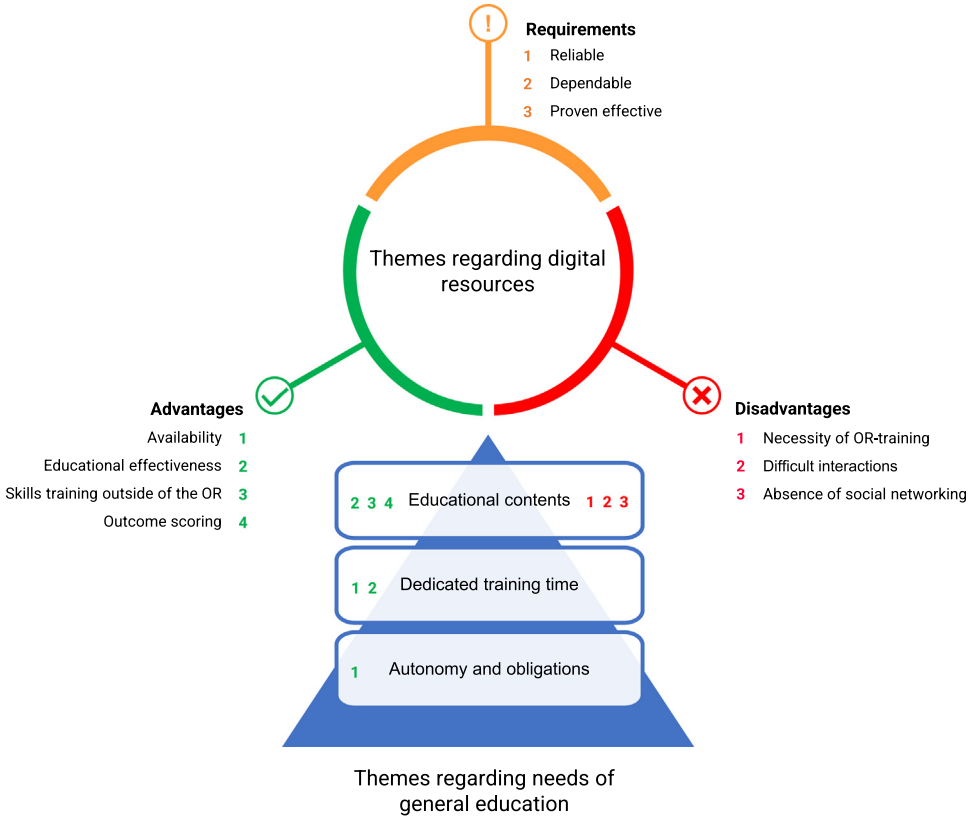

FIGURE 2. Overview of identified themes and their interaction.

while Tables 1 and 2 feature the selected quotations to support the (sub-)themes.

Requirements of Digital Resources

Reliability of the Resource
Residents indicated that it is difficult to assess the reliability of digital resources or if the resource gathers its data from other reliable source(s). Problems with the resource could for example emerge from differences in protocols between hospitals, regions/countries, and the use of outdated information.

Dependability of the Technology
When using digital resources, dependability was deemed essential. Residents remarked that educational technology should work right away and the interaction must be flawless or they will likely become irritated and stop using it.

Proven Technology
Residents indicated a preference for digital resources with scientifically proven effectivity. The residents were unsure if scientific testing and -validation was always successfully performed for the digital resource. If a resource was scientifically supported, some participants questioned the specific skills that are to be trained with the digital resource. For instance, acquiring compound skills as spatial orientation in the abdominal cavity, or dissecting a surgical plane, training solely on a box- or virtual reality (VR) trainer.

Advantages of (Using) Digital Resources

Availability
The most frequently mentioned advantage of using digital educational resources was the possibility to have easily access and extend training. Residents identified three distinct factors to this regard:

1. In your own time

Use of digital resources whenever suited was much appreciated. This enables training within a personal schedule, training at your own pace, and spending more time on subjects if needed or desired. These factors were deemed especially valuable in compulsory training modules, which often need to be completed during busy weeks or in combination with competing obligations and duties.

2. Training from home

Nearly all residents felt that they were already spending enough / too much time in hospital and therefore struggled with the obligation to train in the hospital out of working hours solely for educational purposes. Training from home was deemed to be a suitable solution by some. An additional remarked advantage was that working from home enables training more frequently in shorter time intervals, which may benefit educational output in the end.

3. Reduced traveling time

Residents indicated reduced traveling time as a separate advantage of digital training. This advantage was usually mentioned with the nationally organized courses requiring physical presence in mind. Preparation for such courses, especially the theoretical backgrounds, could possibly be (partially) replaced using digital resources.

Educational Effectiveness
Digital education facilitates more effective and clear education and training according to some, especially in learning anatomy and sequential surgical steps. Residents stated that "traditional" lectures, where residents sit down and listen to PowerPoint supported presentations, are not effective and rather outdated. When asked how they would "build" an educational course, residents preferred a digitally supported theoretical preparation, an in-depth in-person introduction, followed by a hands-on training.

Skills Training Outside of the Operating Room
A major advantage of digital training is the opportunity to practice technical skills outside of the operating room (OR). Laparoscopic (box-) and VR-trainers were the most frequently mentioned modalities. Both types of simulators were deemed useful in improving generic laparoscopy skills such as understanding laparoscopic dimensions, getting used to movements, and practicing hand-eye coordination. Most residents indicated that use of both laparoscopic boxtrainers and VR-trainers is most advantageous early-on in residency training. A perceived additional advantage of using boxtrainers over VR-trainers is the preservation of realistic haptic feedback.

Outcome Scoring
Use of digital resources can inform the user of their performance with outcome scores. Digital dashboards featuring these scores on different modalities may inform both residents and educators. Combining and sharing digital outcomes using leaderboards may nudge use and continued interaction, and enable interaction between national and regional training experiences. Moreover, a skill competition challenge may, besides visibility and

TABLE 1. Selected Participant Quotations on Categories and Themes Regarding Digital Education

Category / Theme	Source	Quote
Requirements		
Reliability of the source	F(emale), 3rd y	The trouble with [digital resources] is that you're not always aware of their reliability, or if they have been made by a local hospital with differences in contents
Dependability of the technology	M(ale), 3rd y	I think that, if you want to educate digitally, it is of the utmost importance that [the technology] works.
Proven effective	M, 2nd y	In my opinion you need to prove that a technology is effective - i.e. that you become more proficient in laparoscopic skills by using a serious game - before you implement resources and make them compulsory. And I think that proving that is not so easy.
Advantages		
Availability		
In your own time	F, 1st y	The benefit of online modules is that you can pause whenever suits you, and continue if you're feeling wide awake again. With that in mind, you would learn more from [an online module] than from being in a classroom all day, mainly due to decrease of your span of attention. And of course it's helpful that you can delve into the backgrounds when it suits you if you think: Oh, I'll have to check this out.
Training from home	F, 3rd y	In another medical center they have a laparoscopy course with a boxtrainer. The residents from that center al say that they love the boxtrainer because it shows your progress. However, I think the setting there is different because you can use the boxtrainer at home. I can imagine that after you go home after a workday, have dinner, and then are able to practice for an h or so. But I'm not going to stay in hospital until 8 or 9 PM just to be able to practice. So if you have a box at home, although it's of course impossible to give a box to everybody, but you could circulate the boxes. Then I think you'll find time to practice more easily.
Reduced traveling time	M, 1st y	Of course there are also benefits; everyone can stay where they are - which sometimes saves two h of travel time. So I think digital education certainly has its advantages, and that we should ask ourselves every time whether physical education is really necessary.
Educational effectiveness	F, 1st y	For example the videos I watch on websites and the information of Incision and other websites, they are really useful to me. If I'm doing something for the first time, it really helps if I've seen it online beforehand - I then know what the steps are and what is the final goal. So yeah, I think that [online education] really helps to this regard as opposed to clinical experience and books.
Skills training outside of the OR	M, 5th y	I think using laparoscopic trainer can be very contributing already in the very early stages of residency. And that usefulness continues. A very recent personal example; if knotting during surgery doesn't go well, it helps me if I do a few of those exercises on the simulator.
Outcome scoring	F, 1st y	I think it would be best [. . .] if would have a curriculum which combines national and regional education with specified occasions - for instance; each m - on which input is required of you [as a resident] and on which you receive feedback.
Disadvantages		
Necessity of OR-training	M, 2nd y	I think that a VR trainer is particularly useful in your initial laparoscopic training, to help you get a feeling for laparoscopy. However, I don't think you're still solving problems by practicing [on a VR trainer] if you're already performing (parts of) surgical interventions by yourself.
Difficult interactions	M, 3rd y	Interaction is just easier when you're together in the same room; everyone can say what they want and you can freely ask questions and give your opinion. I think that you can substitute a lot [digitally] but not everything.
Absence of social networking	F, 1st y	I think that teaching in a classroom with live interaction also has a lot of advantages - for instance asking your questions directly. You hear what others have questions about and their personal story, which i think can also be very helpful. I therefore don't think that [digital education] is easily interchangeable, especially because of the importance of the social aspect which cannot be replaced.

Abbreviations: F,female; M,male; M, month;Y,year

TABLE 2. Selected Participant Quotations on Categories and Themes Regarding General Education.

Category / Theme	Source	Quote
Educational contents		
Educational contents need to be in line with the level and clinical exposure of the audience	F(emale), 6th y	I think you have to assess what the needs of your audience are, because if you can't tailor your teaching to their needs it becomes a very one-dimensional story.
	M(ale), 2nd y	It doesn't make sense for me to be teached in rectal surgery in my second y of residency. Of course that would be interesting, but education on the laparoscopic cholecystectomy, appendectomy or a start of the right sided hemicolectomy would be more useful, because that is where you can make actual progress.
	M, 2nd y	So during my gastrointestinal internship, and just after my trauma rotation, we had vascular surgery education. Of course then I will have to do some memory digging to see what it was all about.
Educational contents need to be practical or aimed at daily practice	F, 2nd y	I loved using the boxtrainer, but what I missed in those exercises was the clinical correlation; just a little explanation on how to do a laparoscopic appendectomy, cholecystectomy or a laparoscopic inguinal hernia corrections.
Expert opinions and insights are highly valued	F, 2nd y	What I'm currently missing in my training - and what was introduced in the livestream surgical education during COVID − 19 is the opportunity to hear several experts speaking about their specialization and passion.
Dedicated training time		
There should be enough educational time for both resident and educator	M, 5th y	Of course time is an important factor. If you're already working fulltime in the clinic, especially with all the extracurricular activities that residents are involved in, it is just hard to free up six, eight, or ten hours to prepare for an educational course.
	F, 1st y	That's a bit of a shame with regard to the educational structure that we have; educational moments are usually organized by the residents and sometimes by a staff-surgeon. However, these moments are often cancelled, because they haven't been planned properly or the surgeon is needed someplace else.
Education should not come at the expense of OR-time	F, 4th y	Dedicated educational time is of course great if it comes instead of, for example work in the outpatient clinic. However, if it is organized at the expense of time spent in the OR, then everyone think that sucks.
Autonomy and obligations		
Autonomy, personal responsibility, and intrinsic motivation are essential (However:. . .)	M, 1st y	Training is partly your own responsibility. If you're not proficient in laparoscopy, you should do everything your power to improve that. So if there is a VR-trainer but you don't use it, I think that it's partly your own fault - and you will probably also get that feedback in the clinic.
If educational tasks are not obligatory and have to be done in a residents' own time, they will not be done	F, 3rd y	The problem is; I already work fulltime, do my shifts, and have some research projects - I'm just not going to stay in hospital for a couple of hours just for the fun of practicing on a VR-trainer. It would be great, but in reality it's just not going to happen.
More summative testing would valuable but not appreciated	M, 3rd y	I think that the training and in particular patient safety would benefit from more testing, but I don't know whether a lot of residents would enjoy it. Of course it is more fun to work with patients, but I think that is secondary to safety.
Younger residents are looking for more structure in the residency curriculum	F, 2nd y	It's also just hard in terms of planning when you're just starting as a resident, to realize exactly what you need to do and what you need to sign up for. So in that respect it's just not very clear, both nationally and regionally.

Abbreviations: F,female; M,male; M, month;Y,year

track of use, also offer opportunities for getting noticed as an outperforming individual.

Disadvantages of (Using) Digital Resources

Necessity of Operating RoomTraining
The vast majority of residents remarked that although digital training can definitely be of value in residency curricula, it cannot replace training in the OR. Residents from the first and second residency year often remarked that they especially valued the feedback and training by the surgeon in the OR. Residents from the third year and higher commented that they needed the experience to become more responsible in the OR, as they feel the need to solve (their own) surgical problems with less strict supervision.

Difficult Interactions
Residents remarked that use of digital resources for communication such as Teams, Webex and Zoom often do not allow for easy communication. Residents experience a barrier preventing them in digitally speaking up. Especially so, when a digital training is given for larger groups, or including participants from multiple locations.

Absence of Social Networking
Residents remarked that educational moments are socially important as they provide much valued opportunities to come together. While digital education can provide alternatives for networking, it cannot provide the same social experience.

General Educational Themes

We found three educational themes of importance for digital learning. The advantages of using digital resources correlated with all three educational themes, while the disadvantages of using digital resources only correlated with the "Educational contents" theme (Fig 2).

Educational Contents
If educational contents do not correspond with the level and exposure of residents, residents' knowledge or skill improvement is believed to be limited. Residents acknowledged the difficulty of organizing just-in-time training opportunities matching the appropriate educational needs of all residents. Hands-on training interactions were preferred over PowerPoint presentations and theoretical education (such as e-learnings). Residents commented that it is especially important to tailor training towards daily (clinical) practice, whether training is hands-on or not. Residents prefer to learn from an experienced surgeon over learning from other residents; the extensive experience of a qualified surgeon is both inspirational and considered to be higher-level educational. Being able to witness surgery on human specimen via a livestream during the pandemic was deemed very relevant; especially since panel discussions between several surgeons and the audience was facilitated. Residents appreciated the availability of surgical podcasts.

Dedicated Training Time
Many residents expressed the need for dedicated time in their and educators' schedule for training and education. Although often scheduled, many residents and their educators could often not attend such trainings due to pressing clinical obligations. Conversely, it was also remarked that this educational time should not come at the expense of OR-time.

Autonomy and Obligations
Residents sought for a balance between autonomy and obligations. Younger residents remarked that they seek more structure and clarity in their educational curricula. They often had a hard time of creating an overview of obligations with regard to planning, organizations, expectations of surgeons, surgical know-how, and essential learning methods and resources. Becoming a proficient surgeon is mostly regarded as one's own responsibility, although the means to get there should be provided by the hospital and educators. Residents struggled to prioritize non-obligatory training with digital resources that need to be done in one's own time - often remarking that those tasks will probably not be performed due to long working hours and other, more pressing, obligations. Residents also stated that they are currently not tested on their training outcome in the current curricula, which should be the case as they believe such a benchmark may in return positively impact efforts and thus their surgical knowledge, skills, and possibly even patient safety. However, when asked if they would like to be tested for these outcomes, most commented that it would increase the number of unwanted obligations, make the residency curriculum more scholastic and would therefore not be appreciated.

CONCLUSIONS

Residents appreciate available digital resources and are eager to use them in their training.

Key requirements of (using) digital resources include that such resources are combined with hands-on training, that they meet resident's educational needs, and that their use does not impose pressure on resident's free time. Perceived disadvantages of using digital resources are all related to the need for interaction with peers: residents feel that in-person interaction with their

peers cannot be replaced in a digital format. Residents in our study felt that earning surgical autonomy starts with acquiring technical skills, followed by attaining procedural knowledge and transfer of these skills to the OR setting.[15,16] In accordance with literature, access to digital skills trainers is highly appreciated, although use of them is not obliged nor standard practice in curricula.[6–8,17,18] Indeed, most residents only accessed these skills trainers in a temporary fashion as part of a technical skills course. Structural integration of these learning modalities in the surgical residency is not common practice to date. Yet, this seems like a logical and much appreciated step which has many precedents internationally– for instance in the Fundamentals of Laparoscopic Surgery.[17,19,20]

Residents specifically appreciated the opportunity to train at home and in their own time. At the same time, they admitted that use of resources in their own time and at home is unlikely to happen if this is not obligated and controlled. This is quite understandable as residents need to relax and unwind when being at home, whilst also fitting in their social obligations and preferences. It is important to realize that practice outcomes could only be assessed validly, if use would be digitally registered. This is problematic as residents indicate that monitoring of practice outcomes on actual use and outcome is undesired. This paradox is not easy to be solved. And one may debate if training for the job, should not be on the job -instead of taking the burden on time needed for residents to recuperate and enjoy their personal life. Especially, when risk at burnout is as high as it is to date among surgical residents. Indeed, it is stated that on the average, residents are at risk of becoming burned out of 51%, with surgical residents being in the highest risk category of 58%.[21,22]

During residency hours, there is not much time to train outside the OR either. Most residents already combine their residency with other tasks deemed important when on the job, such as research, board- or management functions or educational tasks. This, to further augment their CV in competitive times. This problem needs to be recognized by educators and appropriate measures need to be taken. A first step could be to introduce dedicated and protected training time in the working scenario.[23] After all, an inherent and important advantage of using digital training resources is that outcomes can be measured, saved and shared, which offers opportunities for guidance and monitoring. Previous studies concluded that a partially digital simulation-based curriculum improves proficiency, self-confidence, and autonomy. Moreover, routine assessments of surgical procedures enables a more competency-based educational paradigm.[24,25]

Our results and previous studies support a digitally blended, competency-based residency curriculum, with dedicated and protected training time during working hours and digitally shared training results. Establishing such a curriculum could empower surgical residents while providing regular and objective feedback to educators and faculty. Clear educational goals need to be defined before such a curriculum can be established. Moreover, to provide personalized education, curriculum goals and personal goals need to be distinguished. A starting point could be to constitute validated benchmarks for knowledge and surgical skills (both technical and non-technical), which can be used as objectives to work towards. That way, progression can be monitored and supported by the available (digital) resources, or resources still to be developed. For curriculum goals in the earlier years of the residency these resources probably need to be mandatory. Resources may become more optional as the residency progresses successfully– when more autonomy and independence may be expected of residents. Therefore, an overview of available resources needs to be accessible for both residents and educators - regardless of the type of goal that needs to be addressed and the phase in the residency.

Monitoring and comparing surgical performance against a set benchmark of cohorts of residents is both labor- and time consuming. Development of artificial intelligence-based algorithms to generate an individual outcome profile set against the appropriate benchmark would be of great value to support both the trainee and the educator. Individual outcomes that may indicate gaps can then be easily converted into specific training requirements, for instance to reach a pre-determined goal on a VR- or box-trainer. An interesting development to that regard is the Explorer module of the OR Black Box™. This is a data analysis system capable of capturing surgical performance in the OR, as well as side-loading surgical videos to assess outcome. The software is able to analyze operator's surgical performance against set benchmarks as generated by the outcome of peers -making educational progress of surgical residents in the OR objectifiable and thus better trainable.[26–28]

This explorative qualitative study was limited by the characteristics of our participants, namely surgical residents who were intrinsically interested in education. As always in qualitative research, outcomes were not intended for generalizability – despite inclusion of residents from all educational regions and the continuation of interviews until data sufficiency. Further research need to capture the perception of all residents, and also surgical educators and curriculum developers. To elaborate on our findings and to generate quantitative data, a nationwide Delphi study on this topic is currently being established.

In conclusion, Dutch surgical residents state that digital resources may improve their educational experiences,

although they express specific requirements, advantages, and disadvantages of these resources. To successfully adopt and implement proven and required digital resources, additional training should be facilitated in dedicated training time on the job, and educational outcomes should be validly registered. This, in order to successfully adopt and implement digital resources on a larger scale. Future studies must be undertaken to assess the ideal

"mix" of online and offline training in a personalized setup for residents to enable a robust and future-proof surgical residency curriculum.

CONFLICT OF INTERESTS

Nothing to declare.

REFERENCES

1. Khan AA, Rakinic J, Kim RH, Mellinger JD, Ganai S. National trends in general surgery resident exposure to complex oncology-relevant cases. *J Surg Educ*. 2019;76:378–386. https://doi.org/10.1016/j.jsurg.2018.09.003.
2. Purdy AC, de Virgilio C, Kaji AH, et al. Factors sssociated with general surgery residents' operative experience during the COVID-19 pandemic. *JAMA Surg*. 2021;156:767–774. https://doi.org/10.1001/jamasurg.2021.1978.
3. Hoff RG, Frenkel J, Imhof SM. Ten cate O. flexibility in postgraduate medical training in the Netherlands. *Acad Med*. 2018;93:S32–S36. https://doi.org/10.1097/ACM.0000000000002078.
4. Shafi AMA, Atieh AE, Harky A, Sheikh AM, Awad WI. Impact of COVID-19 on cardiac surgical training: our experience in the United Kingdom. *J Card Surg*. 2020;35:1954–1957. https://doi.org/10.1111/jocs.14693.
5. An TW, Henry JK, Igboechi O, et al. How are orthopaedic surgery residencies responding to the COVID-19 pandemic? An assessment of sesident experiences in cities of major virus outbreak. *J Am Acad Orthop Surg*. 2020;28:e679–e685. https://doi.org/10.5435/JAAOS-D-20-00397.
6. IJgosse WM, van Goor H, Luursema JM. Saving robots improves laparoscopic performance: transfer of skills from a serious game to a virtual reality simulator. *Surg Endosc*. 2018;32:3192–3199. https://doi.org/10.1007/s00464-018-6036-0.
7. Thijssen AS, Schijven MP. Contemporary virtual reality laparoscopy simulators: quicksand or solid grounds for assessing surgical trainees? *Am J Surg*. 2010;199:529–541. https://doi.org/10.1016/j.amjsurg.2009.04.015.
8. Ahmet A, Gamze K, Rustem M, Sezen KA. Is video-based education an effective method in surgical education? A systematic review. *J Surg Educ*. 2018;75:1150–1158. https://doi.org/10.1016/j.jsurg.2018.01.014.
9. Braun V, Clarke V. Using thematic analysis in psychology. *Qual Res Psychol*. 2006;3:77–101. https://doi.org/10.1191/1478088706qp063oa.
10. Corbin J, Strauss A. Basics of Qualitative Research. 3rd ed. London: Sage Publications; 2008.
11. O'Brien BC, Harris IB, Beckman TJ, Reed DA, Cook DA. Standards for reporting qualitative research: a synthesis of recommendations. *Acad Med*. 2014;89:1245–1251. https://doi.org/10.1097/ACM.0000000000000388.
12. Varpio L, Ajjawi R, Monrouxe LV, O'Brien BC, Rees CE. Shedding the cobra effect: problematising thematic emergence, triangulation, saturation and member checking. *Med Educ*. 2017;51:40–50. https://doi.org/10.1111/medu.13124.
13. LaDonna KA, Artino AR Jr., Balmer DF. Beyond the guise of saturation: rigor and qualitative interview data. *J Grad Med Educ*. 2021;13:607–611. https://doi.org/10.4300/JGME-D-21-00752.1.
14. VERBI Software. VERBI Software. Berlin, Germany: MAXQDA 2020 [computer software]; 2019 *VERBI Software*.
15. Cadieux DC, Mishra A, Goldszmidt MA. Before the scalpel: exploring surgical residents' preoperative preparatory strategies. *Med Educ*. 2021;55:733–740. https://doi.org/10.1111/medu.14449.
16. Aggarwal R, Grantcharov TP, Darzi A. Framework for systematic training and assessment of technical skills. *J Am Coll Surg*. 2007;204:697–705. https://doi.org/10.1016/j.jamcollsurg.2007.01.016.
17. Schijven MP, Jakimowicz JJ, Broeders IA, Tseng LN. The Eindhoven laparoscopic cholecystectomy training course—improving operating room performance using virtual reality training: results from the first E.A.E.S. accredited virtual reality trainings curriculum. *Surg Endosc*. 2005;19:1220–1226. https://doi.org/10.1007/s00464-004-2240-1.
18. van Dongen KW, van der Wal WA, Rinkes IH, Schijven MP, Broeders IA. Virtual reality training for

endoscopic surgery: voluntary or obligatory? *Surg Endosc*. 2008;22:664–667. https://doi.org/10.1007/s00464-007-9456-9.

19. Society of American Gastrointestinal and Endoscopic Surgeons (SAGES), Fundamentals of laparoscopic surgery 2021 [Available from: Fundamentals of Laparoscopic Surgery (FLS). https://www.flsprogram.org/. Accessed August 31st, 2021.

20. Schijven M, Klaassen R, Jakimowicz J, Terpstra OT. The intercollegiate Basic Surgical Skills Course. *Surg Endosc*. 2003;17:1978–1984. https://doi.org/10.1007/s00464-003-9000-5.

21. Dyrbye L, Shanafelt T. A narrative review on burnout experienced by medical students and residents. *Med Educ*. 2016;50:132–149. https://doi.org/10.1111/medu.12927.

22. Low ZX, Yeo KA, Sharma VK, et al. Prevalence of burnout in Medical and Surgical Residents: a meta-analysis. *Int J Environ Res Public Health*. 2019;16. https://doi.org/10.3390/ijerph16091479.

23. Shetty S, Zevin B, Grantcharov TP, Roberts KE, Duffy AJ. Perceptions, training experiences, and preferences of surgical residents toward laparoscopic simulation training: a resident survey. *J Surg Educ*. 2014;71:727–733. https://doi.org/10.1016/j.jsurg.2014.01.006.

24. Schimpke SW, Larson BM, Veenstra BR, Myers JA, Wojtowicz A, Velasco JM. Do one, do one, teach one: altering the Dogma using simulation-based training to maximize efficiency of Surgical Resident Education. *J Am Coll Surg*. 2020;231:140–148. https://doi.org/10.1016/j.jamcollsurg.2020.04.021.

25. Williams RG, George BC, Bohnen JD, et al. A proposed blueprint for operative performance training, assessment, and certification. *Ann Surg*. 2021;273:701–708. https://doi.org/10.1097/SLA.0000000000004467.

26. Guerlain S, Adams RB, Turrentine FB, et al. Assessing team performance in the operating room: development and use of a "black-box" recorder and other tools for the intraoperative environment. *J Am Coll Surg*. 2005;200:29–37. https://doi.org/10.1016/j.jamcollsurg.2004.08.029.

27. van Dalen A, Jansen M, van Haperen M, et al. Implementing structured team debriefing using a Black Box in the operating room: surveying team satisfaction. *Surg Endosc*. 2020. https://doi.org/10.1007/s00464-020-07526-3.

28. Frederiksen JG, Sorensen SMD, Konge L, et al. Cognitive load and performance in immersive virtual reality versus conventional virtual reality simulation training of laparoscopic surgery: a randomized trial. *Surg Endosc*. 2020;34:1244–1252. https://doi.org/10.1007/s00464-019-06887-8.

SUPPLEMENTARY INFORMATION

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.jsurg.2022.10.015.