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## Using Gagné's "Instructional Design" to teach clinically applicable knowledge in small groups

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## ABSTRACT

**Background:** Anesthesia trainees are expected to perform tasks under non-direct supervision as soon as possible in their clinical training. Often they rely on only superficial rote learning, which might lead to medical errors. We have developed a lesson plan that is based on this educational need using Gagné's Instructional Design for the example of teaching the complex preoperative management of diabetic patients. Our aim was to use Gagne's approach successfully for the teaching of non-procedural skills.

**Methods:** We implemented a comprehensive lesson plan that was developed on the example of a clinical pattern – the preoperative assessment of diabetic patients - using Gagné's systematic nine-step model of instruction design. After the lesson, we analysed the trainees' opinions with the use of a standardized questionnaire.

**Results:** Nine trainees with  $2.1 \pm 0.8$  years of anesthesia experience attended the lesson. The assessment of knowledge revealed in 82% the correct answers to the treatment options, and the residents' overall view on the lecture concept were  $4.8 \pm 0.3$  for lecture concept and realization and  $4.7 \pm 0.5$  regarding motivation, participation and climate.

**Conclusions:** Applying Gagné's Instructional Design model guides seems to effectively guide the development of a comprehensive lesson plan to teach non-procedural skills in a small group setting.

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## 1. Introduction

In many hospitals across the World, the roles and responsibilities of Anesthesia trainees include minimally or non-directly supervised performance of patient clinical encounters early in their training [1–3]. Although trainees usually get an introduction in their Departments, some face new tasks that go beyond the syllabus or general learning plan under variable teaching and assessment qualities, with potential lack of expert role models and correct feedback on their performance [4]. Although there have been improvements with the introduction of competency-based curricula [5–7], workplace-based assessments [8,9] and the use of simulated patients [10], early career trainees sometimes need to rely on local guidelines or Standard Operating Procedures to carry out their tasks with little supervision [11]. These memorized 'cognitive aids' that achieve 'rote learning' due to simple repetition [12] include little reflective critical thinking,

which might lead to medical errors [13]. One example of such medical errors is an inadequate pre-operative clinical approach to diabetic patients. The in-hospital management of diabetic patients is complex and often includes intravenous (IV) insulin [14–18], which can lead to errors in prescribing anti-diabetic drugs in the perioperative period [19] and have serious consequences for the safety of the patient.

In order to closely address this learning need and narrow the respective gap, we aimed to create a lesson plan based on trainee learning needs related to a ubiquitous preoperative clinical problem: the preoperative management of diabetic patients scheduled for elective surgery. We chose Gagné's Instructional Design [20] as a theoretical framework for the teaching and learning method in small groups. Such frameworks for thinking can provide shared understandings which can help improve the quality of instructional design, course, lesson planning, teaching, learning and assessment [21]. Gagné's model [22] is based on how humans process information: his principles refer to actions from both teachers and learners during the teaching process [23]. In Gagné's theory of instructional design, the developer of the lesson plan must first pin down the type of outcome to be achieved; only after that should

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instructional events be tailored to achieve this outcome.

Gagné's approach is widely used for procedural skills teaching [23–26], and specifically for complex psychomotor skills education [20,22–24,26,27], although it is significantly less used for the teaching of knowledge as described herein.

## 2. Materials & methods

Gagné's systematic model of instruction describes nine steps [20] (Table 1) that are designed to ensure that all objectives are addressed while the session flows, to enhance the learning process. We applied this structure to small group tutorials of 1 h for anaesthesia trainees, in terms of the management of preoperative

diabetic patients. As a pre-requisite, the trainees were encouraged to read the local diabetes management Standard Operating Procedures and the current international guidelines [14,15], which were provided electronically before the session.

Gagné's 9 steps of 'Instructional Design'

- 1) *Gain attention*: To ensure that trainees are ready to learn and are curious about the topic, we started with a thought-provoking question to draw their attention to the difficulty of prescriptions during pre-operative assessment of diabetic patients [16,17]. A PowerPoint presentation was used for this purpose.
- 2) *Inform the trainees of the objectives*: Three learning outcomes were introduced to make sure that all of the trainees were aware

**Table 1**  
Lecture outline.

Step	Aim	Timing (min)	Activity
1	Gain attention	5	Tutor explains the rationale of the session Start the lesson with a thought-provoking fact: "Why do trainees think that it is so difficult to get the insulin prescription right when a diabetic patient undergoes surgery?" Use a multimedia visual stimulus: PowerPoint presentation of a case-scenario of a diabetic patient scheduled for surgery. Distribute a note-taking guide with the crucial points and guidelines, and with space for written notes.
2	Inform the trainees of the objectives	3	Present the slide with the learning outcomes  1. Classify different anti-diabetic drugs and describe their main uses. 2. Differentiate between recent guidelines for perioperative management of diabetic patients, and compare them with the departmental protocol. Appreciate the commonalities and differences between these different guidelines. 3. Summarise the main preoperative approaches available according to given anti-diabetic drugs. Follow with a small group discussion, so that trainees can reflect on these learning outcomes. Give input and suggest changes when needed. Ask about topics that are not mentioned and need to be included in the list.
3	Stimulate recall of prior learning	10	Have the trainees review the preoperative approach to diabetic patients as case discussion in 'buzz groups'.  Divide the group into three, and have each subgroup discuss a different case of a patient with the specific therapeutic management of diabetes: Case 1: Diabetic managed through their diet. Case 2: Diabetic taking oral antidiabetic drugs Case 3: Diabetic under insulin therapy. Review the use and classification of the common anti-diabetic drugs (Objective 1). Ask the trainees about any previous experiences and difficulties that they have encountered in prescribing oral antidiabetic drugs and insulin regimes.
4	Present the stimulus	8	Give trainees a thorough insight into the most recent guidelines on preoperative management of diabetic patients. Stop twice during this presentation to ask the trainees actively to pinpoint new knowledge, and to compare this with previously learned approaches.
5	Provide learning guidance	10	Go back to cases #2 and #3 of section 3. Review the examples and show the trainees the optimal way to write the pre-operative prescriptions according to both the local hospital protocols and the international guidelines (these should not be mutually exclusive). Include in the presentation a simulation of the filling in of the relevant hospital forms, and a flowchart (if existent) of all of the steps to be taken.
6	Elicit performance	10	Use a role-playing exercise to rehearse the practice of writing correct prescriptions. Sort the audience into pairs and give out cards with a case vignette to the trainees playing the patient. The goal is to simulate an anaesthesia appointment with different types of diabetic patients (i.e., insulin therapy, oral antidiabetics, injectable non-insulin agents) for different types of surgery (i.e., ambulatory vs. in-hospital admission), and to advise on the correct prescriptions for these drugs, accordingly.
7	Provide feedback	5	Observe each pair of trainees as they perform the role-playing and (preferably) take notes for your feedback. For larger groups, consider more facilitators to help with feedback delivery. Offer individual and immediate feedback during the performances where corrections might be needed. Deliver feedback in a safe, non-judgemental learning environment. Invite the other trainees to provide constructive feedback.
8	Assess performance	5	Ask the trainees to turn to their note-taking guide and to now individually answer the final multiple-choice questions in the booklet. After that, the answers are discussed in the group, and the correct ones are given. Check for how many questions each trainee got right.
9	Enhance retention and transfer	5	To enhance retention, insist that trainees practice what they have learned with real patients during their pre-anaesthesia appointments. Distribute a decision flowchart similar to the one shown in step 5 for trainees to carry with them. Inform trainees to contact their teaching supervisors through the usual channels (beeper, e-mail) when questions arise. Close the session by asking for the last open questions and answer these. Review the key points as a final statement, and asking for feedback from the trainees using a questionnaire.

of the same objective for the planned lesson. After this, the trainees discussed their expectations regarding these learning objectives in small groups.

- 3) *Stimulate recall of prerequisite learning*: At this point, the trainees were allocated to three 'buzz groups' (i.e., groups of three people to respond to a specific question), each with a different case scenario (see Appendix 1). To stimulate recall of earlier learned content, the trainees had to recommend a preoperative approach to their given case. This was followed by review of the current classification of commonly used anti-diabetic drugs. To conclude this step, each group delivered their findings, experiences or difficulties encountered in prescribing oral antidiabetic drugs, non-insulin injectables and insulin regimes.
- 4) *Present the stimulus material*: This section addressed pre-anesthesia recommendations for diabetic patients [14,15], including details of local protocols and published international perioperative guidelines. To facilitate interaction, tables were displayed to indicate how the preoperative assessment guidelines of diabetics have been simplified over the years, with emphasis on the most recent guidelines.
- 5) *Provide learning guidance*: Explanation of the appropriate actions leading to correct management of diabetic surgical patients through discussions of the previously used case scenarios (See Appendix 1).
- 6) *Elicit the performance*: This step allowed the trainees to practice and train for the correct prescriptions. The trainees were grouped in pairs for role-playing of a pre-anesthesia appointment with a diabetic patient. Role cards were distributed for the trainees who performed the 'patient', including a brief medical history. The goal was that the trainees playing 'the anesthetist' would apply the correct preoperative prescription scheme for each 'patient'. Trainees would take turns at being the patients. Eight prescription examples were passed around on cards.
- 7) *Provide feedback about the performance correctness*: During the role-play, constructive and corrective feedback was given, with a focus on the application to the clinical problem.
- 8) *Assess the performance*: The teacher assessed the performance through observation of the role-play. To evaluate the immediate effectiveness of the lesson, the learning outcomes were assessed using multiple-choice questions before the end of the session. The correct answers were discussed with the trainees.
- 9) *Enhance retention and transfer*: The trainees practiced what they learned during the pre-anesthetic visit to the Department, with a senior supervision and their feedback. To support the transfer of competencies into clinical practice, a decision chart was uploaded on the Department intranet. Finally, the last open questions were answered, with the key points reviewed, and the session closed.

The detailed designed stepwise lesson plan for the teaching is presented in Table 1, which includes all of teaching material and assessment forms needed.

### 2.1. Evaluation

At the end of the session, participants were asked to answer a closed-end Likert scale questionnaire (see appendix 2) aimed to assess the trainees' judgment of the preparedness to transfer and apply the gained knowledge into their daily clinical practice (Kirkpatrick's evaluation level I and II).

The 23-Item questionnaire was divided in 3 sections [Category 1 - Lecture Concept and Realization (twelve questions), Category 2 - Motivation, Participation and Climate (seven questions), and Category 3 - Workload and Level of Difficulty (four questions)]. For the Category 1 (lecture concept and realization) and Category 2

(motivation, participation & climate) trainees could choose five options, from 1, which was strongly disagree, 2 disagree, 3 undecided, 4 agree and 5 strongly agree. For Category 3 (workload & level of difficulty), choices included 1 which was very low, 2 low, 3 undecided, 4 high and 5 very high. The questions were based on a standardized course evaluation tool (EvaSys®, Electric Paper Evaluations systeme GmbH, Lüneburg, Deutschland) in use at the University of Bern (<https://scanserveruls.unibe.ch/evasy/indexeva.php>). The questionnaire included a brief explanation of the purpose of the questionnaire and how to complete it. Before its use in the session, the questionnaire was piloted and assessed for face validity with the help of two lecturers of the University of Bern and two trainees of the Department of Anesthesiology and Pain Therapy of the Bern University Hospital.

By answering the questionnaire, trainees gave written informed consent to code, analyse and publish the data. Data is shown as mean  $\pm$  SD or percentages. The Federal Ethics Commission (Kantonale Ethikkommission für die Forschung) reviewed the protocol and waived further need for ethical approval (BASEC 2018-00449).

### 3. Results

Nine trainees (5 men and 4 women) attended the small-group lesson. We had a questionnaire response rate of 100%. The average age was  $32 \pm 1.4$  years with  $2 \pm 0.8$  years of anesthesia experience. The reasons for attending the lecture were: 1) "the subject is relevant to my practice" (66%), 2) "because it is an obligatory lecture" (55%), 3) "particular interest in the topic" (33%), 4) "because of the teacher" (22%), and 5) "in preparation for an exam" (10%).

The assessment of knowledge revealed in 82% the correct answers to the treatment options and the residents view on the teaching session are summarized in Table 2. The residents' overall view were  $4.8 \pm 0.3$  on lecture concept and  $4.7 \pm 0.5$  regarding motivation, participation and climate.

**Table 2**

Descriptive analyses for the rating scale items with three categories (no missing values). For Categories 1 and 2 a Likert scale 1–5 was used where 1 = strongly disagree, 2 = disagree, 3 = undecided, 4 = agree and 5 = strongly agree. For Category 3, the Likert scale ranged from 1 = very low, 2 = low, 3 = undecided, 4 = high and 5 = very high.

Item	Mean $\pm$ SD
<b>Category 1: Lecture concept and realization</b>	
Easy to follow in English	4.8 $\pm$ 0.4
Learning aims clear and transparent	4.7 $\pm$ 0.4
The coherence of sequential order of topics	4.9 $\pm$ 0.3
Relevance of the study content	4.4 $\pm$ 0.5
Broader context and interconnections	4.6 $\pm$ 0.5
Sufficient connection between theory and practice	4.8 $\pm$ 0.4
Time was appropriate	5.0 $\pm$ 0.0
The teacher was well prepared	4.8 $\pm$ 0.4
Teacher's inputs were easy to follow	4.9 $\pm$ 0.3
Teacher spoke clearly	5.0 $\pm$ 0.0
The teacher showed an interest in student learning success	4.4 $\pm$ 0.5
<b>Category 2: Motivation, participation &amp; climate</b>	
Course was motivating	4.4 $\pm$ 0.5
The teacher made a quiet and undisturbed progress	4.8 $\pm$ 0.4
Enough opportunities to ask questions	4.9 $\pm$ 0.3
Teacher's answers were clear	5.0 $\pm$ 0.0
Appropriate use of media	4.7 $\pm$ 0.5
Helpful use of media	4.8 $\pm$ 0.4
Usefulness of additional materials	4.6 $\pm$ 0.5
<b>Category 3: Workload &amp; level of difficulty</b>	
The workload for preparation and follow-up	2.4 $\pm$ 0.7
Level of difficulty	2.8 $\pm$ 0.4
Amount of presented new subject	2.9 $\pm$ 0.3
Amount of previous knowledge of the subject	3.0 $\pm$ 0.9

After the session, we had one spontaneous e-mail from a participant sending us photos of the session, praising our idea and stating that the “idea with role-playing and multimedia was super-effective”.

#### 4. Discussion

During the development of this lecture proposal, we considered some adaptations to Gagné’s nine instructional steps [20]:

1: Gain attention: By starting with a thought-provoking question, we used the Socratic method of exploration and created an interactive atmosphere [28]. The slide projection was intended to raise the interest of the trainees in the topic and to address different learning styles. This was mirrored in trainee’s answers, as they attributed high scores to the appropriateness and helpfulness of the media and the additional materials used.

2: Inform the trainees of the outcomes: This helped the trainees understand what they were going to learn and why. According to Vroom’s Expectancy Theory of Motivation [29], presentation of the learning outcomes before the instruction begins turns on the internal process of expectancy and enhances motivation to complete the lesson, which reinforces the intake of information. Knowing what the learning outcomes are sets a standard of gained competence against which the trainees can self-assess. Finally, having the trainees discuss the proposed learning outcomes might start a critical reflection on why so many prescription mistakes happen.

3: Stimulate recall of prior learning: Constructivists claim that learning is facilitated by activation of prior knowledge [30]. This information retrieval from long-term memory activates previously learned information [31] and serves as an ‘effort-reduction’ strategy, to lower the cognitive load while creating ‘space’ for new cognitive demands. Instructional design can, therefore, be used to reduce the cognitive load in learners [32]. Interactive group discussions and enquiries about previous clinical experience facilitate such recall [23,24].

4: Present stimulus: This section presents the new content in an organised and meaningful fashion [23,24]. Tables help the trainees to learn in ‘chunks’, by facilitating the assimilation of the new information [32,33].

5: Provide learning guidance: The interactive learning started at this point, with a demonstration of a correctly managed ‘real-world example’. This learning through demonstration or ‘modelling’ is considered to be particularly effective [34]. Inclusion of the hospital forms and a decision table introduced tools that help the trainees to encode information for storage in long-term memory [23,24].

6: Elicit performance: Role play was chosen because it mimics the work conditions and focuses on communication and effective interactions [35]. Repetition of the content during the role play increases the likelihood of retention, and gives the trainees the opportunity to confirm their correct understanding [23].

7, 8, 9: Provide feedback, assess performance and enhance retention and transfer: to provide timely feedback after the completion of the learning task [36], this was offered while the trainees were practicing their role play. The effectiveness of the lesson was assessed using multiple-choice questions to define the achieved learning outcomes, as multiple-choice questions are widely used and recognized in anesthesia to define the breadth of medical knowledge [37]. We enhanced the retention and transfer by providing a decision table via the Departmental intranet platform as an ‘on-the-job aid’ for guidance.

Gagné’s nine steps provided a useful and systematic learning methodology, even when we expanded his approach from individual skills teaching to the education of cognitive knowledge (i.e. the ability to acquire factual information). In the development of this session, a few factors needed to be considered, including the

nature of the learning goals, the allocated time, the institutional constraints, the way the content was delivered, the number and levels of the trainees and their preferences. In the face of these limitations, Gagné’s instructional design model showed apparent advantages: (i) it guaranteed that the learning objectives were unambiguous and standardised; (ii) it ensured that the learning was aligned with the objectives; and (iii) it ascertains that the learning activities were similar amongst the trainees and that they can be further maintained by different tutors. We have also shown that this can be easily applied, while still allowing for context-rich teaching, embedded in real-life application and relevance [24].

It is, however, a design with limitations. It is a very detailed model, and teachers might spend a lot of time on the development and planning phase, sorting the actions into different sections. Some of this sorting can be quite rigid [26,38,39], and it might turn off some of more creative tutors who might wish to, for example, change the order of the learning events. Additionally, while being widely used when teaching procedural skills [23–25,28], eliciting performance in a theoretical session can be demanding. Our strategy to create a new interactive learning part to fit this section in the form of role-playing was challenging and time consuming. Implementation of such role-playing in larger group can be difficult. An important issue during the role-playing was to provide individual feedback. We solved this problem by organising the trainees into groups of two, with ‘patient role’ feedback provided.

The type of evaluation chosen is also not devoid of flaws. First, we observed a low trainee participation (only nine participants), which may have induced participation bias. This session was held in a weekly session for anesthesia trainees that occur while surgeries are still running. It is therefore impossible to predict how many trainees attend. Due to the success of this session, we have considered doing a second round, both with the intent to gather more participants and also to use a pre-post assessment with a more robust tool, but this was not possible because all trainee lectures have now been cancelled for several months due to the Coronavirus epidemic.

Finally, long-term retention and improved patient care need to be assessed as part of this educational instruction in order to properly evaluate the relationship between the teacher workload and improved patient care for this instructional design.

#### 5. Conclusion

This article reports how Gagné’s model of instructional design for teaching can be applied to teaching cognitive knowledge. We have produced an effective and comprehensive lesson plan for teaching a theoretical framework in small groups, to be applied and translated into clinical practice. We could show that our approach was satisfactory for teaching of a relevant clinical problem.

#### Ethics approval and consent to participate

The Kantonale Ethikkommission für die Forschung Bern reviewed the protocol and waived the need for approval.

#### Consent for publication

Not applicable.

#### Availability of data and material

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

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## Authors' contributions

JBE designed the study, analysed and interpreted the questionnaire data. RG was a major contributor in writing the manuscript and thoroughly reviewed it. Both authors read and approved the final manuscript.

## CRedit authorship contribution statement

**Joana Berger-Estilita:** Conceptualization, Formal analysis, Investigation, Visualization, Writing - original draft, Project administration. **Robert Greif:** Methodology, Validation, Resources, Data curation, Writing - review & editing, Supervision.

## Declaration of competing interest

The authors declare that they have no competing interests.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.tacc.2020.08.002>.

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