Canadian Medical Education Journal

Brief Reports

Documenting medical students' use of self-explanations: tool development and initial validity evidence

Documentation de l'usage de l'auto-explication par les étudiants en médecine : élaboration d'un outil et premières données de validité

Elise Vachon Lachiver,[1] Martine Chamberland,[2] Linda Bergeron,[1] Jean Setrakian,[2] Hassiba Chebbihi,[2] Christina St-Onge[1,2]

[1]Paul Grand'Maison de la Société des médecins de l'Université de Sherbrooke research chair in medical education, Université de Sherbrooke, Quebec, Canada; [2]Department of Medicine, Université de Sherbrooke, Quebec, Canada.

Correspondence to: Christina St-Onge, Department of Medicine, Université de Sherbrooke 3001, 12e Avenue Nord, Sherbrooke, Canada; phone: 1-819-821-8000 # 75047; email: christina.st-onge@usherbrooke.ca

Published ahead of issue: Jul 21, 2025; published: Sept 10, 2025. CMEJ 2025, 16(4) Available at https://doi.org/10.36834/cmej.78199

Abstract

Introduction: Self-explanation (SE), an individual learning strategy for the development of clinical reasoning skills, has been implemented in undergraduate medical curricula. A tool for documenting students' appropriate use of SE is needed to ensure benefit on learning. The objective of this project was to develop such a tool and report on evidence of its validity.

Methods: We used DeVellis's eight steps to develop the tool. Assessors applied the tool to 85 audio-recorded SEs. We calculated students' mean number of inferences (biomedical, clinical, monitoring) and case elements used when self-explaining to document validity evidence of content. We used interrater agreement, with intraclass correlation coefficients, to document validity evidence of response processes.

Results: Three assessors documented the students' use of SE with the tool. They found means of 13.33 to 17.76 biomedical inferences, 16.27 to 27.04 clinical inferences, 2.03 to 3.10 monitoring statements, and listed 21.77 to 26.87 case elements. Interrater reliability varied from 0.53 to 0.96.

Discussion: We developed the tool using the principles underlying SE. The way students used SE aligned with our expectations. Assessors used the tool in a consistent way. The tool could document students' use of SE in experimental or educational contexts.

Résumé

Introduction : L'auto-explication (AE), une activité pédagogique favorisant l'acquisition de compétences en raisonnement clinique, a été étudiée et implantée dans des programmes médicaux. Un outil est nécessaire pour évaluer la qualité de l'AE. L'objectif de ce projet était de développer un outil évaluant la qualité de l'AE et de démontrer sa validité.

Méthodes : Nous avons suivi les huit étapes de DeVellis pour élaborer l'outil. Les évaluateurs ont appliqué l'outil à 85 AE enregistrées. Pour la validité du contenu, nous avons calculé le nombre moyen d'inférences (biomédicales, cliniques, de monitoring) et d'éléments du cas utilisés. Pour la validité des processus de réponse, nous avons utilisé l'accord inter-juges.

Résultats : Trois évaluateurs ont mesuré la qualité de l'AE des étudiants. Ils ont trouvé en moyenne 13,33 à 17,76 inférences biomédicales, 16,27 à 27,04 inférences cliniques, 2,03 à 3,10 éléments de monitoring, et 21,77 à 26,87 éléments du cas. La fidélité inter-juges variait de 0,53 à 0,96.

Discussion : L'outil a été développé sur les principes de l'AE. L'AE des étudiants correspond à nos attentes. Les évaluateurs ont utilisé l'outil d'une façon standardisée. L'outil pourrait être utile pour documenter l'engagement des étudiants à faire de l'AE en contexte expérimental ou pédagogique.

Introduction

Clinical reasoning skills are central to medicine; thus, learning strategies that help foster these skills have garnered much attention. In recent years, several authors have shown that self-explanation (SE) is a learning strategy that supports students' knowledge-building for clinical reasoning.[1-6] Consequently, authors have recommended its implementation in medical curricula.[7]

SE is an individual learner-centered approach that actively involves students in knowledge building. When used with clinical cases as the learning material, SE requires students to generate, by and for themselves, explanations about the elements of the cases to deepen their knowledge and understanding. In the context of solving cases, SE fosters prior knowledge activation, knowledge elaboration, linking pathophysiological mechanisms (or underlying domain principles) to clinical manifestations and, in so doing, allows students to identify gaps in their knowledge.[3,8-9]

Empirical data support the positive impact of SE on students' subsequent clinical reasoning skills.[3-5] Learning increases when students generate inferences and not only paraphrases. Inferences can be clinical or biomedical when they relate to underlying mechanisms.[4] Biomedical inferences are particularly helpful to deepen students' understanding.[10] Monitoring statements reflect students' appreciation of possible gaps in their knowledge, which also supports learning.[4] The quantity of SEs generated by students appears to be important for learning: high self-explainers benefit more than low self-explainers.[4]

SE is implemented in medical training because it shows promise.[1,11] Monitoring students' use of SE can inform the program about their engagement in the activity. However, to our knowledge, no monitoring tools exist to document students' use of SE.[9,12,13] In the present paper, we describe the development of a tool to document students' use of SE and aim to provide initial validity evidence.

Methods

We developed the tool following DeVellis's eight-step framework.[14] While this framework is usually used to guide the development of surveys and scales, the process was easy to adapt to our context. Below, we depict each step of the process, except for Steps 5 and 8, which were not undertaken. Step 5 (Inclusion of a validation scale) invites the researchers to include a validation scale in the tool (e.g., social desirability), which was not relevant to the purposes of this study. Step 8 refers to optimizing the scale. We did not formally complete step 8 as a standalone process but incorporated it into the iterative development of the tool.

Data collection context

Our team implemented SE within a large-scale undergraduate medical education curriculum renewal.[15] The preclinical program was deployed over two and a half years and was divided into five blocks of activities per year. These blocks were based on undifferentiated clinical problems, and end with an integration week, during which the SE activity takes place. For each SE activity, students individually solved three clinical cases on a web-based platform using verbal SE. Students self-explained for a minimum of six minutes to a maximum of 15 minutes. These SEs were audio-recorded. In total there were 33 cases over two and a half years. We used whole clinical cases (history, physical examination, initial laboratory tests) of approximately 350 words, related to the content covered in the blocks preceding the integration week, and designed to be sufficiently challenging for students. The program opted to have students vocalize their SE instead of writing them, thinking it would be a less demanding task.

Step 1. Determine the concept to be measured

Our concept was "students' generated self-explanations". More specifically, we were interested in documenting if students' SE in an authentic educational context were consistent with the educational principles underlying SE.[6]

Step 2. Creating the item pool

We opted to use the educational principles of SE as the foundation for developing the items of our tool (see Table 1). We embedded some principles in the design of the activity (Principles 1, 2, 3, and 7). We created items for principles that involve student actions (Principles 4, 5 and 6). MC, who has extensive experience with SE, proposed four items, aligned with the principles[6] and with what is known about characteristics of SE utterances that impact learning.[4] These items underwent further vetting in the subsequent steps of tool development: 1- number of biomedical inferences; 2- number of clinical inferences; 3- number of monitoring statements; 4- number of clinical elements included in the case and used by the student to generate SE.

Table 1. SE principles and associated items

Principles[15]	Items and scale to document the use of SE by participants or students.
1. Is an individual, learner-centered learning activity	The activity was designed as a web activity to be done at home with individual logging onto a platform.
2. Requires prior knowledge activation	The activity was designed to limit the time spent on the case so the students had to cope with their own knowledge rather than reviewing their books.
3. Requires the learner to elaborate on current knowledge while working with the learning material	The working material consists of three cases, provided to students. The cases represent a sample of content seen in class previously so the students can elaborate with their current knowledge. Plus, specific prompts are incorporated to encourage the elaboration.
4. Requires the learner to link elements of the learning material or prior knowledge to underlying principles (i.e., biomedical knowledge) to deepen their understanding	Clinical inferences and biomedical inferences show students use of SE. (Frequency)
5. Requires the learner to analyze the problem in a systematic and deliberate way	Use of different elements of the case shows students use of SE. (Frequency)
6. Allows the learner to monitor the state of their knowledge, becoming aware of gaps and ambiguities	Monitoring statements shows student engagement in the activity. (Frequency)
7. Requires the learning material to be sufficiently challenging to require the individual to engage in deep knowledge-building	The desirable difficulty level of the cases was planned and validated by clinical teachers.

Step 3. Determining the measurement format

We focused on the number of utterances per category as a proxy to use inferences, monitoring statements and case elements used during students' self-explanation (see definitions in Appendix A). The challenge with SE is its audio nature, requiring assessors to listen to recordings for 6 to 15 minutes per student. To maintain attention and ensure consistency among assessors, we provided a sheet to map students' inferences (see Appendix B). This tool could also be used to monitor written SEs. The tool comprised a list of case elements in the center of a printed page. Assessors identified and noted students' biomedical inferences on the left and clinical inferences on the right (see Appendix B for an example).

Step 4. Review of the item pool by the experts

Two experts, one familiar with the educational innovation and the other familiar with the concept of SE, reviewed the tool for clarity, appropriateness, and alignment with SE principles. We consulted each expert independently. We asked them to judge the clarity and appropriateness of the four items and if they aligned with principles 4, 5, and 6. Subsequently, we met them to discuss their perceptions and suggestions for improvement. The tool is presented in Appendix A.

Step 6. Pilot testing the tool

Data. We randomly selected SE from 60 students from the 2017-2021 cohort at two time points (the first activity and the last activity of the first year), to include SE from students at different levels and a variety of cases. Students had signed a consent form to allow the release of their data for this study. We anonymized the electronic SE documents. The university's ethics review board approved the project (#2017-1488).

Procedure. Three assessors were asked to make a judgement about the presence or not of the items. They documented students' SE independently of each other. First, MC and JS pilot-tested the tool on 15 audio-recorded SEs. To test whether other assessors could document SEs with our tool, we added EB to the team. During her training, she listened to one SE with an accompanying completed grid. Then, she independently assessed five SEs for calibration purposes. We then formed three pairs of assessors: MC-JS, MC-EB, JS-EB.

We used 85 SE audio recordings and assigned them as follows: Pair 1 documented SEs for 30 randomly chosen recordings from the three clinical cases of Activity 1, Pair 2 documented SEs for 30 randomly selected recordings from the same three clinical cases of Activity 1, and Pair 3 documented SEs for the remaining 25 recordings from the three clinical cases of Activity 5. We chose this number of SE to meet requirements for analysis of the results while ensuring that the workload was manageable for assessors.

Documentation and analysis. We chose to document two types of validity evidence –content, and response process– defined by Downing's 2003 interpretation of the Standards for Educational and Psychological Testing.[16]

We documented Content evidence during the tool development, guided by a robust conceptual definition of our construct. Expert review of the tool and subsequent adaptation achieved ensured the tool's content closely aligned with our target construct: students' use of SEs. Furthermore, we documented students' SE by counting the number of inferences (biomedical, clinical, and monitoring statements) and case elements used by students, as identified by assessors, per case and per student. We reported mean and standard deviations per activity and pairs.

Since our tool requires assessors' judgment, providing evidence of response processes was crucial. This involved ensuring assessors could consistently understand each item's definition and accurately identify and count them similarly.[16,17] We used intraclass correlation coefficients (ICC) with two-way mixed effects, absolute agreement, and single assessor/measurement for each pair of users. ICC values between 0.5 and 0.75 indicate moderate reliability, while values between 0.75 and 0.90 represent good reliability.[18]

Results

Step 7. Evaluation of items

***Average number of each item in student SE recordings*.** On average, students made 13.33 to 17.76 biomedical inferences, 16.27 to 27.04 clinical inferences, 2.03 to 3.10 monitoring statements, and listed 21.77 to 26.87 case elements (Table 2). In addition, the number of inferences is quite similar for each pair of assessors during the same activity. Assessors identified more clinical inferences in Activity 5 than in Activity 1.

***Interrater agreement*.** ICCs varied between 0.81 to 0.96 for biomedical inferences, 0.81 to 0.90 for clinical inferences, 0.53 to 0.78 for monitoring statements, and 0.76 to 0.84 for case elements (see Table 2). The ICC between clinical teachers MC and JS calculated for the monitoring statements is 0.53, representing moderate to good reliability.[18]

Table 2. Means (standard deviations) and intraclass coefficient for each item and assessor.

Activity	N	Assessor	Biomedical inferences		Clinical inferences		Monitoring statements		Case elements	
			Mean (SD)	ICC	Mean (SD)	ICC	Mean (SD)	ICC	Mean (SD)	ICC
1	30	MC	15.30 (10.38)	0.92	17.03 (6.31)	0.81 [0.32:0.93]	2.70 (2.23)	0.53	26.87 (9.00)	0.84
		JS	17.17 (11.46)	[0.82:0.96]	19.97 (7.08)		2.03 (1.73)	[0.23:0.75]	23.53 (7.91)	[0.39:0.94]
1	30	JS	16.53 (8.08)	0.81	16.27 (6.70)	0.87	3.10 (1.81)	0.78	21.77 (6.68)	0.76
		EB	13.33 (6.44)	[0.30:0.93]	17.63 (7.94)	[0.74:0.94]	2.63 (1.73)	[0.57:0.89]	26.23 (7.15)	[-0.05.:0.93]
5	25	MC	17.76 (11.23)	0.96	26.84 (7.51)	0.90	2.60 (2.04)	0.76	25.84 (5.67)	0.78
		EB	17.24 (11.34)	[0.91:0.98]	27.04 (8.33)	[0.78:0.95]	2.64 (1.75)	[0.52:0.89]	23.48 (6.14)	[0.41:0.91]

Discussion

SE is a useful learning strategy in several fields, including medical diagnostic reasoning. We developed a tool to document medical students' SEs. Results from our study show evidence supporting this tool's use to monitor students' SEs.

Evidence of content

We documented biomedical inferences, clinical inferences, and monitoring statements in all the students' SE recordings, leading us to conclude that students used SE as intended. The development process described above ensured that we embedded content representativity. The higher biomedical inferences in Activity 1 suggest a lower level of familiarity with cases, exploring from organ system and physiological perspectives.[10] Students made more clinical inferences for Activity 5 than Activity 1, suggesting developing clinical knowledge over time.[10]

Evidence of response process.

Raters identified a similar number of statements. This validity evidence is important because it shows that monitoring students' engagement in SE educational activities does not require additional costs by adding more assessors. However, the intraclass correlation was notably lower for monitoring statements, particularly between a specific pair of assessors. The limited monitoring statements can provide an explanation for this. Discerning what constitutes a monitoring statement from a simple expression of uncertainty in the student's think aloud may also be a factor in this finding.

There are increasing numbers of studies on SE in HPE,[3,11,19–24] with many using diagnostic accuracy[3,19,23,24] or clinical reasoning tests[11,20,22] as outcome measures. Our tool captures a different and intermediate implementation outcome: whether students actually use SE during the educational activity appropriately. The tool itself may be utilized to understand how SE contributes to knowledge organization and clinical reasoning development. Thus, this tool could be used to monitor SE in an implementation or research context. It could potentially be used in other disciplines that employ self-explanation by adjusting biomedical and clinical inferences to correspond with the types of inferences in their respective fields (underlying mechanisms vs. practical aspects). Alternatively, it could be utilized in other health science disciplines, provided that evaluators are trained to identify the types of segments within a self-explanation. Finally, this tool could measure changes over time in SE as students' expertise develops and offer more targeted guidance on enhancing SE for greater benefit.

Limitations include a single-institution context and one specific way of operationalizing SE which restricts generalization. The two assessors were clinicians, and the third was a resident physician. This background knowledge might be essential for assessors using this tool to categorize SE. Nevertheless, the rigorous and reproducible development process using DeVellis's model makes it applicable to the development of similar tools.

Conclusion

We combined a conceptual framework using principles underlying SE with the widely used DeVellis process to develop a monitoring tool for assessing the alignment of the SE learning activity with its intended implementation. Ensuring this alignment is essential for guaranteeing that students benefit from evidence-based educational practices. Future studies should replicate the use of the tool with different cases and assessors to enhance its transferability.

Conflicts of Interest: Christina St-Onge is an editor for the CMEJ. She adhered to the CMEJ policy on editors as authors. The authors report there are no competing interests to declare
Funding: This work was funded by the Société des Médecins de l'Université de Sherbrooke (Fonds de développement pédagogique 2019)
Edited by: Henry Moon (co-senior section editor); Cindy Schmidt (co-senior section editor); Marcel D'Eon (editor-in-chief)
Acknowledgments: We thank Dr. Émilie Blais (EB), who contributed to evaluating students' self-explanation.

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Appendix A – Tool to assess the quality of students' SE

Definition of items for the assessment of quality of self-explanation

Inferences: The student makes an elaboration, links two ideas, or links one ideas with their prior knowledge. The student adds information beyond what is explicitly mentioned in the text. The student goes beyond reading or paraphrasing. Inferences may refer to clinical or biomedical elements.

1- Clinical inferences – Quantity

Definition of the item: number of clinical inferences made by the student

Clinical inferences: The student makes inferences with clinical content: related to predisposing factors, symptoms, signs, laboratory abnormalities, or the treatment (refers to elements contained in an illness script).

<u>*Notes:*</u>

1- When the student simply provides a medical term for an element (shortness of breath = dyspnea): this is not considered an inference, but a paraphrase.
2- Exceptionally, if the student does not explicitly mention the diagnosis, but seems to talk about a specific diagnosis, this is considered a clinical inference.

On the document used to map the student's SE, a clinical inference is represented by a line/arrow that points toward:
1- Disease categories (e.g. pulmonary infections)
2- Illness scripts
3- Diagnoses

2- Biomedical inferences – Quantity

Definition: number of biomedical inferences made by the student

Biomedical inferences: The student refers to/explicates a global mechanism, a pathophysiological mechanism or a molecular mechanism to explain an element of the problem.

<u>*Notes:*</u>

1- Interpretations of physical signs are considered biomedical inferences.
2- When the student interprets a quantitative case element (e.g., blood pressure) for which no normal value is provided, this is considered a biomedical inference. However, if the normal value is provided in the case (e.g., laboratory), and the student only says that the result is normal or abnormal, this is considered a paraphrase.

On the document used to map the student's SE, a biomedical inference is represented by a line/arrow that points toward:

1- Molecular mechanisms
2- Pathophysiological mechanisms
3- Global mechanisms : organ (e.g., lung) or process (e.g., infection)

3- Monitoring statements – Quantity

Definition of the item: number of monitoring statements made by the student.

Monitoring statements: The student monitors the state of their knowledge. The student expresses their understanding or misunderstanding, confusion or questioning about a case element. The student recognizes what they know, what is ambiguous, and the limits and errors in their current knowledge.

Note:
Questioning uncertainty about the clinical case is not considered a monitoring statement.

On the document used to map the student's SE, a monitoring statement is represented with an "M" added to the element that prompted monitoring.

4- Case elements used by the student - Quantity

Definition of the item: number of case elements used by the student.

Case elements used by the student: Each of the specific case elements listed in the middle column of the map for which the student expresses an inference (biomedical or clinical) or a monitoring statement.

On the document used to map the student's SE, total number of case elements for which there are lines/arrows or "M."

Appendix B. Example of a first-year medical student self-explanation map