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Article

Integration of Basic Science into Virtual Patient Cases to Enhance Clinical Reasoning Skills

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Abstract

Objective: To explore medical students' perceptions towards the integration of basic science into virtual patient (VP) cases and to evaluate the impact on self-perceived clinical reasoning (CR) ability. Methods: We conducted a qualitative and explorative study involving 14 medical students during their clinical placement within rheumatology. Basic science elements were integrated into five VP scenarios using the virtual interactive case simulator. Students' perceptions were explored through the analysis of semi-structured interviews with seven students, followed by Malterud's systematic text condensation. Results: The analysis yielded five themes: (i) appreciation of basic science knowledge, (ii) ambiguity towards basic science as an obstacle for integration, (iii) the effect of integration on self-perceived clinical reasoning, (iv) engaging design of the basic science integration, and (v) low knowledge of clinical reasoning concepts. Despite positive perceptions, students demonstrated low motivation for independent engagement in practice. The students who completed the intervention reported enhanced self-perceived CR abilities, as evidenced by more comprehensive thinking processes. Conclusions: Basic science integration into VP cases was positively perceived and appeared to enhance self-perceived CR abilities. However, students' reluctance to independently engage posed implementation challenges. Early introduction of CR learning objectives and CR as a conceptual framework may improve motivation and provide coherence for the integration of basic science in the clinical components of medical education.

Keywords: virtual patients; clinical reasoning; basic science

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1. Introduction

For almost a century, many medical programmes have begun their curriculum by educating students in basic science for two to three years, followed by clinically orientated courses that often included various kinds of "clerkships". The desired outcome is that physicians possess adequate clinical reasoning skills at graduation, strengthened by a profound knowledge in basic science. Clinical reasoning (CR) can be defined as a cognitive process in which clinicians gather and analyse clinical information, generate diagnostic hypotheses, and formulate management plans. It comprises both analytical and non-analytical reasoning processes, integrating biomedical knowledge with experiential understanding to arrive at appropriate decisions regarding patient care [1]. An source of

disappointment frequently raised, ever since, by both clinical teachers and students is that a large part of the previously acquired basic science skills rapidly decay or are "forgotten" by physicians the during clinical years [2]. In defence of this notion, the observation of practicing physicians has shown that they do not report that they are actively integrating basic science in their clinical reasoning [3]. However, it has been clearly shown that they do—they are just not consciously aware of it [4]. As many physicians also take on the responsibility of being clinical teachers, it is not surprising that students are exposed to their views, and students indeed report conflicting emotions between knowing the expectations that they acquire basic science knowledge. While they acknowledge its importance, they also report uncertainty of its relevance and utility [5–7]. Previous research has shown that the integration of basic science in clinical education is necessary and beneficial for healthcare professionals, both in education and practice [8]. It has been shown to increase the ability of clinical reasoning (CR), to apply new knowledge into challenging or unfamiliar clinical situations or to explain why a treatment is a part of a guideline [5]. There also seems to be a significant increase in recall when new information is presented within a familair and meaningful context [9]. Not surprisingly, basic science integration also strengthens patient communication skills, e.g., through the ability to inform patients of various treatment options and provide answers to questions relevant to patients [10].

The integration of basic science can take different forms, and a comprehensive overview is beyond the scope of this project. However, in this study, we are referring to integration as a backward transfer approach, explaining clinical symptoms and findings from a basic science perspective, using pathophysiology, anatomy or biochemistry [11]. This is preferably achieved in a clinical learning environment [7], but a current challenge in clinical education is to find suitable patient encounters that fit the students' learning goals [12]. Virtual patients (VPs) have been proposed to be an effective way of exposing students to more patient cases, also ensuring that students encounter diagnoses and presentations that serve the needs of their learning outcomes, regardless of the patients they happen to encounter during their clinical rotations [13,14]. Students perform better at examinations and report higher satisfaction frequencies after using VPs compared to other forms of studying, but it is still unclear if their CR ability is enhanced [12,15,16]. As VPs often are restricted to a clinical context [16], it is also not clear how active integration of basic science within VPs could be best designed, and how students would perceive this integration. Our aim was therefore to explore medical students' perceptions and emotions towards the integration of basic science aspects in VP cases and to evaluate the possible impact of this integration on students' self-perception of acquirement of CR ability. A secondary aim was to collect information that could be utilised for the development of a concise model with key concepts and strategies for how to integrate basic science concepts in case-based CR training platforms, which could be useful for teachers and for curricular development.

2. Methods

This study was designed using a qualitative and explorative approach evaluating the integration of basic science in VP cases within a one-week clinical placement in rheumatology at Karolinska University Hospital, during the 5th and 6th semesters of the medical programme at Karolinska Institute. The integration was implemented into five VP scenarios which were already being used for training purposes. The assignment was to be completed at any time during the week of the placement at the Karolinska University Hospital. A voluntary response sampling method was used, although participation in performing the VP cases, as well as the basic science seminar, was a compulsory part of the placement. Participation in the interviews was entirely voluntary to ensure informed consent and avoid any perceived coercion. Students were informed about the interview opportunity at

the beginning of the placement week. Of the 14 students available during the clinical placements, 7 volunteered to participate in interviews, with all seven completing the interviews. Given the narrow and specific research question of this study, along with the richness of data obtained from the in-depth interviews (mean duration: 39 min), this sample size was considered appropriate for the exploratory nature of this study. During the last day of the week, the VP cases were discussed in addition to a one-hour seminar dedicated to the discussion of basic science integration. The VP simulations that were used were created using the virtual interactive case simulator (VIC), a software tool for developing virtual patients (VPs) created by the Toronto General Hospital Department of Anaesthesia Perioperative Interactive Education [17]. The basic science integration was designed as a scientific summary, explaining the underlying pathophysiology of the symptoms and findings within the cases in a "Why/How"-mode. The summary was attached as a document to the cases, and the students were informed about the assignment at the beginning of the placement. Significant effort was devoted by the research team to making the explanations short and concise to fulfil the notion of utility and utility value. Therefore, the integration did not aim to be comprehensive, but rather focused on key concepts to enhance cognitive coherence, i.e., understanding. All texts were then revised by a specialist in rheumatology, as well as by a basic scientist specialising in inflammatory diseases.

2.1. Thematic Content Analysis

The students' perceptions and emotional responses to basic science, as well as their confidence in and development of CR skills were explored through semi-structured interviews, performed by the primary researcher. All interviews were audio-recorded and transcribed verbatim. The interview guide (Supplementary Materials S1 and S2) was developed based on a validated questionnaire for assessing VP design, with an emphasis on CR [18]. The interview guide was continuously evaluated and revised iteratively during the interviews to further clarify important content [19]. The transcriptions were coded and analysed thematically using Malterud's systematic text condensation, based on Giorgi's psychological phenomenological analysis [20] and adhering to the Consolidated Criteria for Reporting Qualitative Research (COREQ)-guidelines for qualitative studies [21].

It should be emphasised that this study focused on students' self-perceived CR skills rather than objective measures of CR performance. The interviews explored students' subjective experiences of how the integration of basic science influenced their reasoning processes, including their awareness of more comprehensive thinking patterns and generation of differential diagnoses.

This methodological approach was divided into four steps: (i) an overall view was first obtained, and preliminary themes were identified accordingly; (ii) meaning units were sorted into themes and subthemes (this step was repeated several times when themes diverged or converged); (iii) meaning units within a theme were then condensed into a constructed quotation—a condensation—representing the main content of the theme in thoughts and emotions; (iv) different themes and condensations were organised into a logical structure to describe and form a general concept.

All transcriptions were read by the entire research team. The primary researcher conducted the initial thematic analysis, without using any software or AI tools, and after the third step, the condensations and themes were presented to the rest of the team, prompting a collaborative discussion that led to the refinement of categories and improved alignment with the data. Finally, categories, quotes, and condensations were translated into English by the research team. Following this final step, all transcriptions were re-read one last time by the primary researcher to ensure that the themes and general concepts were in conformity with the material. Given this study's prioritisation of interpretative depth over

participant validation, it was deemed that recruitment of additional participants would not significantly enhance the analytical outcomes.

2.2. Reflexivity

The team consisted of four researchers with complemental expertise and qualifications: one male physician intern (pedagogy track) (KR); one male physician-intern (research track) and doctoral student in medical education (AB); one female nurse specialised in intensive care with a doctorate in VPs (CG); and one male senior consultant rheumatologist and associate professor of rheumatology (IP). The team aimed to maintain reflexivity during data collection and analysis through discussion and critical collaborative spirit, in order to acknowledge situated positionality and its potential influence on methodological choices and the interpretation of the findings. For instance, KR did not have extensive training in performing in-depth interviews or following analytical pipelines but brought a relatively recent perspective as a medical student, ensuring proximity to the material and the participants' point of view. AB developed the VP cases used in this study, under the supervision of IP, CG, and consultant rheumatologist colleagues at Karolinska University Hospital. CG is an experienced researcher in VP simulations and the VP platform VIC, and she assisted in the development of the VP cases. IP is an experienced researcher within rheumatology and medical education, and an examiner in courses within internal medicine at KI. To minimise potential influence on participants, KR, who had no teaching or assessor role in the medical programme and was not involved in assessing students during their placement, was solely responsible for participant recruitment and conducting the interviews. While AB developed the VP cases under supervision, he had no direct contact with study participants during data collection. Nevertheless, we acknowledge that the team members' involvement in VP development and familiarity with the intervention could potentially influence data interpretation. To mitigate this, the entire research team upheld reflexive discussions throughout the analysis process, critically examining assumptions and interpretations to ensure that the findings remained grounded in the data rather than preconceived expectations.

2.3. Ethical Considerations

Written consent was obtained from all the participants, and no personal identifying information was collected in this study. The students were pseudonymised by being assigned a random four-digit number that was only known to the primary researcher. The list of numbers and names were stored on a safe server. Thus, our study did not pose any risk to the participants' integrity.

As the questions asked only concerned the participants' thoughts about their perception of basic science and their development of clinical reasoning skills, the questions were deemed not to cause any significant risk of discomfort.

Ethical approval was granted: the study protocol was reviewed and approved by the Swedish Ethical Review Authority (diary number: 2022-04437-01).

3. Results

Of the 14 students tasked with completing five basic science-enhanced VP cases, seven were interviewed, representing a 50% volunteer response rate, with a mean interview duration of 39 min (range 26 min–1 h 5 min). There were no dropouts. After analysing the data, we identified five themes, which illustrated the students' perceptions of basic science integration into VP cases and its possible impact on acquirement of CR skills.

Overall, the students appeared to appreciate basic knowledge. However, this appreciation also came with mixed feelings and ambiguity due to earlier experiences of a high

workload, too many details, and boring lectures. Nevertheless, the integration of basic science into virtual patient cases seemed to enhance self-perception of acquirement of CR ability. A strong objection is, however, that the general knowledge of CR as a framework was overall very low.

Each identified theme consists of several subthemes, which are explored and described below. The themes can be viewed as separate entities; however, when analysed together, they also illustrate a possible weakness in the learning outcomes of the medical programme, leading to a proposed recommendation in the conclusion.

3.1. Theme 1: Appreciation of Basic Science Knowledge and Its Role in Future Work

Condensation: *The body of knowledge from our first years is the basis and literally everything. When meeting a sick patient, I want to understand what is happening inside the body. Maybe that knowledge will make me think broader and able to reason with myself to come up with the right conclusion and management even though I don't know every clinical detail. That would probably make me feel more self-confident in making decisions. I also think it is a great foundation for new knowledge and that it brings a feeling of safety, both for me and for the patient.*

All participating students expressed great appreciation of their basic science knowledge and acknowledged that it was an important part for their future work in several aspects. There were some differences in the definition of what could be referred to as basic science, but a general assumption was that it consisted of theoretical knowledge acquired until the beginning of clinical rotations. Students reported the importance of having a deeper understanding of diseases, as well as that this knowledge might make them less dependent on practical algorithm guidelines in the future and create a sense of safety. Representative quotes are found in Table 1 (section Theme 1a). The students also reported that basic science affected their learning of new clinical knowledge when serving as a foundation (Table 1; Theme 1b). Students spontaneously mentioned patient communication skills as one potential benefit of basic science (Table 1; Theme 1c). Not surprisingly, the students also mentioned that basic science helped them understand the clinical setting and practice during their rotations. However, when they did not understand, they were reluctant to ask questions, since they were aware that they "should know" those aspects of basic knowledge (Table 1; Theme 1d).

Table 1. Representative quotes from in-depth interviews.

Quote Identification	Quote
Theme 1: Appreciation of basic science knowledge and its role in future work	
1 a	
#7743, female	"I think it is greatly important. (. . .) I want to know why things are happening"
#2878, female	"It is a platform that gives me a feeling of safety"
#1921, female	"I think it is better to learn why things work the way they do. If something happened and I would be alone, I might feel more confident in my ability to manage a patient if I know the underlying cause of symptoms and not just that it is a sign of a particular disease"
1 b	
#8960, male	"The biggest advantage is that new knowledge gets better consolidated"
#6064, male	"It is like a skeleton that you can build new knowledge on"

Table 1. *Cont.*

Quote Identification	Quote
1 c	
#2878, female	"I think it is really important to have it with you when you speak to patients about their conditions (. . .) to explain why it is like what it is and increase adherence"
#7743, female	"As a future doctor, I want to be able to explain the biological background to my patients"
1 d	
#6064, male	"I would never have been able to follow their reasoning in the department of haematology if I didn't have the knowledge from former years. I wouldn't say I understood it all, but it kept my head over the water
#1921, female	"When standing in front of a senior doc- tor, I don't check up on things I don't know. It is a general assumption that you should already know it"
Theme 2: Ambiguity towards basic science in practice as an obstacle for integration	
2 a	
#7743, female	"I didn't even open them"
#2878, female	"Oh, my God. This will be so boring"
#4572, female	"It was a far cry from a welcome gift, really"
2 b	
#6064, male	"I have to admit I didn't open them. . . I didn't have time"
#7743, female	"Lack of time, really!"
2 c	
#1158, female	"I was sitting by my- self on the bed. The room was lit, but very quiet and calm. I didn't have any other distractions such as music, and I made them all at once"
2 d	
#4572, female	"I think laboratory work is so boring. Standing there in white coats, fussing about. . ."
#8960, male	"It is a lot of information, and you feel lousy if you don't get it all"
#2878, female	"I am so glad it is over"
#8960, male	"Yeah, well. . . if one re- cons it was hard, you don't want to think about it and you push the very knowledge out of your brain"
Theme 3: The effect of basic science integration on self-perception of clinical reasoning	
3 a	
#2878, female	"It got more of a comprehensive feeling but not entirely complete and finished (. . .). It was like a bubble in my head where I had both the patient and the disease. I asked myself all kinds of ques- tions to see whether it fits or not. (. . .) It was like I was juggling the patients' symptoms—like a puzzle."
#8960, male	"I think I found more differentials"
#1921, female	"If that is what basic science is all about, then it absolutely affected my ability to ask questions that I had not thought of earlier, and I also sought for risk factors and complications"
3 b	
#8960, male	"It is much more fun to go backwards and couple a clinical manifestation with basic science and in that way, reading the documents was rewarding"

Table 1. *Cont.*

Quote Identification	Quote
Theme 4: An attractive design of basic science integration	
4 a	
#7743, female	"Verbal seminars are better when discussing concepts and different ideas"
#1158, female	"It is convenient to follow the reasoning thread of someone else. (. . .) You also connect things like the lecturer's shirt (sic!) to a subject and the way they are talking about things. It is like you hear it in your head afterwards"
4 b	
#7743, female	"It is nice with text when you want to memorise difficult names and classifications (. . .). One can also go back and have a second look
#1158, female	"A document with a lot of text is hard to make interesting. Just Times New Roman against a white background. I would rather have them integrated in the cases"
Theme 5: Low knowledge of the concept of clinical reasoning	
5 a	
#8960, male	"No, I don't know what it is (. . .). I don't think I can recall that it has been mentioned, no"
#4572, female	"It is a mix of theory and some kind of, what shall I say, it is not practical like when you see a patient, but it is not like you are reading a book either"
5 b	
#7743, Female	"To exclude everything that isn't probable"
#1921, female	"I don't know how to explain this. It is like you begin with finding out why the patient is coming to you. Then you start to riddle, first from the patient history and then from the physical examination, laboratory tests, and so on. Then you guess what it is."

#: number

3.2. Theme 2: Ambiguity Towards Basic Science in Practice as an Obstacle for Integration

Condensation: *Just by seeing the documents, I felt exhausted. I waited as long as I could before I opened them. It brought back memories of endless lectures, laboratory work, and strange names of enzymes. Even though I am proud I managed, those years were so draining. A part of me will always remember how bad I felt, and I thought I would have to drop out.*

In sharp contrast to their previously mentioned positive perception, all students except two expressed frustration and almost reluctance when given the documents on basic science integration. Only a few studied the papers in detail, and half of the students did not complete the voluntary assignment, reading only some of the documents. Even the students reporting the strongest positive emotions to basic science showed limited effort (Table 1; Theme 2a). As the main reason for not studying the documents, students reported lack of time (Table 1; Theme 2b). However, this was, paradoxically, not reported as the main problem when completing the virtual patient cases, despite the participants' own statements, indicating that they had invested substantial time and effort, and that the cases were completed in environments that were well suited for the task (Table 1; Theme 2c). Instead, a large part of the ambiguity appeared to be associated with bad experiences and memories of their teaching environment during their first basic science years. This period was associated with long lectures, enormous amount of detail, and difficult terminology. The high workload also seemed to have spurred feelings of self-doubt and even a fear of having to drop out. One student even made the connection that his bad memories affected his ability to remember the knowledge (Table 1; Theme 2d).

3.3. Theme 3: The Effect of Basic Science Integration on Self-Perception of Clinical Reasoning

Condensation: *I was a bit reluctant at first but once I opened the documents, I found them very useful. I got a better understanding both diagnosis and other possible complications. It was like I suddenly had a parallel process in my mind that analysed the findings along the way, and this made me more aware of questions that were most important. Like I was thinking in a more comprehensive way. In a way, it was more fun.*

Those who performed the intervention reported that the integration had a positive effect on their management of the cases, including a more comprehensive sense of understanding and a parallel reasoning process a that accompanied task performance. The foundation for this reasoning was reported to form the basic science integration and was perceived as satisfying. Other signs of an enhanced clinical reasoning ability were the tendency to think of more differential diagnoses, asking new and different questions, and seeking complications and risk factors (Table 1; Theme 3a). Finally, some students found the basic science integration to be fun! (Table 1; Theme 3b).

3.4. Theme 4: An Attractive Design of Basic Science Integration

Condensation: *I generally prefer verbal seminars to written documents any day of the week but in this case, I would prefer both, as written content does have benefits when one needs to learn difficult words or details. When you miss something during a seminar, it is gone, but in written documents you can go back and learn at your own pace. If one was to integrate basic science texts in the virtual patient cases, the most important thing would probably be to divide into smaller pieces so that they could be provided continuously during the case.*

Most students reported that they normally preferred oral seminars over written content but in the case of basic science integration into virtual patient cases, they appreciated to have them both. The advantages of verbal seminars seemed to be the opportunity to ask questions but also the opportunity to follow someone else's reasoning process as a model for how to perform the integration (Table 1; Theme 4a). The written content, however, seemed to be preferred when it came to learning details and the ability to revisit the material at the students' own pace. Students also suggested that the text should be divided into smaller parts and integrated into the flow of the VP cases (Table 1; Theme 4b).

3.5. Theme 5: Low Knowledge of the Concept of Clinical Reasoning

Condensation: *I haven't heard the term "clinical reasoning" before. Anyhow, I might be able to guess what it is about. I guess it is about seeing the patient as a whole; it seems neither theoretical nor practical and it is hard to explain but taking everything into account and eventually producing a diagnosis.*

Even though some of the students had a vague feeling of what clinical reasoning was, particularly when completing the VP cases, upon being asked a direct question, whether they were familiar with the concept or not, none answered that they were. Trying to define the concept, the assumptions about what CR consisted of were diverse (Table 1; Theme 5a). It was notable, however, that by reflecting on the concept, the participants gradually developed possible explanations that aligned with established definitions of clinical reasoning, including the exclusion of differential diagnoses and hypotheses, culminating with a diagnosis and a management plan (Table 1; Theme 5b). Reasoning about it, however, required substantial time and effort, and it was obvious that clinical reasoning was not a concept that could be spontaneously recalled, nor was it present in the students' perceptions of their previous education or regarded as a specific aim in their competence development.

4. Discussion

This study aimed to explore students' perceptions and emotions towards the integration of basic science into VP cases and to evaluate its possible effect on the students' self-perception regarding the acquisition of CR skills. We emphasise that our findings are based on students' subjective reports rather than objective measurements of CR skills. While this approach provided valuable insights into students' experiences and perceived changes in their reasoning processes, future research employing validated CR assessment tools would be valuable to corroborate these self-reported improvements. Overall, students' perceptions towards basic science were positive, but their motivation for performing the integrative activity on their own was unexpectedly low. Even so, the students who completed the activity reported an improvement in their CR ability; however, none of the students were familiar with the concept of "clinical reasoning" beforehand. This is not surprising, since CR, as a concept, is not an explicit part of the students' learning outcomes. However, we argue that this could have several implications, including the absence of a clear goal for the integration of basic science.

The finding that students report a general appreciation of basic science knowledge, especially in improved recall and enhanced patient interaction, echoes previous research [5]. However, this study included a unique feature, as the students' undertaking of basic science integration was not actively facilitated or compulsory, which may have offered insights into how integration is perceived and performed in practice. Our results raise the question whether students, when responsible for their own learning, are motivated to integrate basic science into clinical training or if it is something they only engage in when they are clearly assigned to an activity. Previous studies have predominantly explored integration through structured and guided interventions [5,6,22]. It could therefore be speculated that the positive perceptions of basic science integration observed in these studies may partially be due to an "euphemism", i.e., the integration is an appealing concept but remains largely theoretical.

The fact that the students were not motivated to read the integrative documents may not be surprising from a general point of view; it is expected that students may feel reluctance towards additional work. However, the paradox between students' appreciation of basic science and their reluctance to engage with the integration material represents a key finding with important implications. Even if students referred to lack of time as the main reason for not reading the documents, they were assigned sufficient time for the VP cases, suggesting that time constraints alone do not fully explain their behaviour. Several factors may contribute to this discrepancy. The negative emotions associated with previous basic science education may have created an aversion that persists despite intellectual appreciation. In addition, without explicit learning objectives around CR, students may have lacked a concrete goal towards which the integration activity would contribute, perceiving it as supplementary rather than essential to their development. This finding challenges the assumption that awareness of educational value automatically drives engagement and suggests that successful integration requires not only well-designed materials but also the framing of learning objectives.

A fundamental prerequisite for self-regulated learning and determination is the presence of a long-term motivational goal, and that goal has to be clearly defined and understood [23,24]. As previously mentioned, the main outcome of basic science integration in clinical training is the enhancement of CR skills. However, in this study, none of the students could clearly define CR as a concept, and what one is not aware of cannot serve as an efficient learning goal. If students were made aware of the positive impact on their CR readiness and if the concept of CR was introduced in medical education, preferably starting from early years, this might concretise the development of medical knowledge.

It has previously been shown that CR is rarely expressed as an explicit learning outcome in the U.S. and in European countries, and recommendations for how learning objectives related to CR could be implemented have been proposed [25]. Furthermore, specified learning activities for both students and trainers have been developed [26]. Even though clear efforts have been made, implementation is still scarce. Hence, the identification of contexts where CR should be an explicit learning outcome remains a need.

Obvious limitations of this study are that it is a small study that reflects a local context within one medical programme in Sweden, with a low number of participants, which constrains transferability. The interview rounds were concluded based on convenience rather than an assessment of information power [27], which could have limited the richness and credibility of the findings. In addition, the study participants had relatively limited clinical experience and might therefore not have experienced the advantages of basic science in clinical practice. Moreover, the challenges associated with previous basic science terms were recent, and we therefore cannot determine whether the perceptions might be different in later terms. Exploring previously unknown perceptions in-depth interviews may introduce a bias, as participants becomes familiar with the definitions, and begin to recognise the potential benefits during the discussion. Therefore, their responses may subconsciously construct a new narrative. Furthermore, reliance on self-reported perceptions of CR abilities, while providing valuable insights into students' experiences, may not capture actual changes in CR performance.

As a final note, for future research, the participants reported that they valued continuous integration during rotations in the hospital environment. However, this was to some extent hindered by their hesitation to ask senior colleagues questions related to basic science, as they perceived that they perhaps "should have known this themselves" from previous years. This might be an interesting subject for further research, as it is also reinforced by the limited awareness of the fact that the lack of basic science integration is not a personal shortcoming, but a structural problem. It might also be interesting to chart which aspects of basic science are most easily forgotten yet remain clinically important.

5. Conclusions

Overall, the absence of a well-defined goal for integrating basic science into clinical training is a problem that needs to be addressed. We are not aiming for a "meta-learning" approach, i.e., to learn how to learn, but rather for addressing the importance of knowing "why to learn". Even though there will always be aspects of medical education that will require the use external motivational factors, an incremental mindset might be better sustained by helping students understand the overall aim and broader purpose of their education. Furthermore, embedding basic science explanations directly within VP interfaces, rather than providing them as external documents, may improve engagement and reduce the perceived burden of integration activities. Relying heavily on medical students' curiosity and innate constructive mindsets may not be sufficient, and an early introduction of clinical reasoning as a conceptual construct to be progressively acquired during medical education might be a key factor that could increase student motivation, contributing to a sense of coherence and a willingness to persist in their learning despite the challenges encountered during and after the basic science terms.

Supplementary Materials: The following supporting information can be downloaded at https://www.mdpi.com/article/10.3390/info16110950/s1. Supplementary Materials S1. The interview guide used for the evaluation of basic science integration and its effect on self-perceived development of clinical reasoning skills in Swedish (original language). Supplementary Materials S2. Interview guide used for the evaluation of basic science integration and its effect on self-perceived development of clinical reasoning skills in English (translated).

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Institutional Review Board Statement: This study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Swedish Ethical Review Authority (registration number: 2022-04437-01; date of approval: 11 October 2022).

Informed Consent Statement: Informed consent was obtained from all participants involved in this study, and no personal identifying information was collected.

Data Availability Statement: The datasets generated and analysed during this study are available from the corresponding author upon reasonable request. Access to data will be granted following appropriate ethical review and data sharing agreements.

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