A Collaborative Learning Environment of the Medical Diagnosis on the Basis of the Clinical Reasoning Theory

Mohamed Abderraouf Ferradji and Abdelmadjid Zidani
LaSTIC laboratory, Department of Computing, Batna University, Batna, Algeria

Keywords: Clinical Reasoning, Medical Education, Medical Pedagogy, Collaborative Learning, Social Knowledge Building, Synchronous Interaction, Group Awareness.

Abstract: In collaborative clinical learning field, several recent pertinent studies showed that gathering learners with their tutor still insufficient to improve students' learning quality and knowledge acquisition. Consequently, focusing attention on professional skills within a collaboration environment seems to be the most appropriate way to reach the wished learning objectives, particularly in a complex specialty such as medical diagnosis learning. In this paper, we firstly introduce the concept of medical diagnosis from cognitive studies view that have been performed in the field of medical education. Then, we will discuss our shared web environment designed to support distance diagnosis learning, which aims to promote knowledge co-construction and collaboration between learners.

1 INTRODUCTION

In the medical field, the competencies of making a diagnosis are refined through the good structuring of an important mass of medical knowledge in the doctor's memory, and the mastery of relevant reasoning process (Bordage, 2005; Eva, 2005; Nendaz et al., 2005). However, the observation of learning strategies in the medicine faculties of Algeria, showed that the classical objective-based pedagogy represent the most used learning method. Indeed, we led an investigation mainly based on observations and interviews with a medical staff within a gynaecology and obstetrics emergency unit in Algeria.

In fact the typical used approach is based on the direct transmission of knowledge and considers learner as an inactive entity with a great capacity of theoretical knowledge memorization. Even in the internships occurring at hospitals and before the patient's bed, we have noticed that the clinician teacher has not always time and pedagogic strategy that allow him to explain the approach of the used reasoning and the mobilized knowledge to achieve the stated diagnosis (Nendaz et al., 2005). Moreover, the quality of the acquired knowledge depends on the richness of the met cases during the internship cycle. To overcome these challenges, many medicine faculties across the world have introduced the collaborative learning methods (Quénu-Joiron, 2002).

The integration of these learning methods in the medicine faculties of Algeria requires radical changes in terms of educative systems and even on the faculties' infrastructures. Moreover, this pedagogic activity is based on learning in small groups of learners and its organization in classroom mode is not always easy (Ortega, 2005). Especially in Algeria with the area of (2 381 741 Km^2) and that doesn't allow the very limited number of experimented doctors to contribute to the pedagogical activities in all medicine faculties. This fact limits significantly the learners' opportunities, in far southern areas of benefiting from their experiences in a fair way. This observation ensues directly from our study about the imbalance in terms of specialized doctors' availability compared to the north of the country. The direction into the distant collaborative learning support tools may bring more flexibility and fluency in time and in space of diagnosis learning (Quénu-Joiron, 2002).

Besides that, the fact of gathering learners with a tutor in a team, either in classroom or distance mode, is not enough to improve the learning quality and knowledge acquisition, as supplementary factors related to the professional skills, on one hand, and to the collaboration, on the other hand, must be

Ferradji, M. and Zidani, A.
A Collaborative Learning Environment of the Medical Diagnosis on the Basis of the Clinical Reasoning Theory.
In *Proceedings of the International Conference on Information and Communication Technologies for Ageing Well and e-Health (ICT4AWE 2016)*, pages 80-87
ISBN: 978-989-758-180-9

considered.

In this paper, we propose a web-based learning environment supporting the collaboration, the coordination and the communication between a group of learners who are geographically distant, and share a common task of elaborating a medical diagnosis in synchronous mode. Finally, to increase our environment efficiency, we have considered the most pertinent cognitive studies achieved in the field of medical education, as well as the researches dedicated to the clinical reasoning process modeling.

2 CLINICAL REASONING

In the medical education field, the major of the definitions related to the clinical reasoning process that have been proposed agree on a common point. It is about the perception of such process as a set of mental activities that allow the clinician to make the right decision while dealing with a specific clinical situation (Barrows, 1980; Higgs, 2008). Furthermore, studies that have been achieved in this area have revealed that doctors use diverse methods of reasoning. These methods are mainly based on two classes of reasoning: analytical and non-analytical processes as mentioned by Pelaccia (2011), as well as the study achieved by Croskerry (2005).

According to the analytical reasoning approach, a physician can explicitly draw his own reasoning process (Duquerroux, 2009; Evans, 2008). Through such drawing he may then establish a relationship between the patient's signs or symptoms and the identification of the categories of diseases associated with them ((Eva, 2005). Such kind of reasoning is generally used by doctors who have very little experience and which must always follow a set of steps that allow them to confirm a diagnosis. It is even used in complex clinical or soon encountered cases, where the doctor can not directly establish a diagnosis and will have to resort to reasoning efforts to reach the final diagnosis (Edwards et al., 2004).

However, according to the non-analytic approach, the physician cannot explain the used reasoning process (Duquerroux, 2009; Evans, 2008). So the non-analytical reasoning can be used in typical cases where the physician can make a diagnosis without deploying reasoning efforts, especially when the considered case is characterized by its similarity with a specific disease prototype. Such reasoning way is mainly used by experienced doctors who can systematically make diagnoses while mobilizing a minimum of their conscience through a direct projection of the current processed case on a similar well known one (Croskerry, 2005; Eva, 2005;Nendaz et al., 2005; Pottier & Planchon, 2011).

In this paper we mainly focus our work on the complex process of hypothetical-deductive reasoning (Figure 1). Such process may be considered as a part of the analytical process and, remains as the most used method in the clinical training field (Coderre et al., 2003). According to the analytical approach, the physician proposes a set of early hypotheses, based on the preliminary interaction with the patient, which seem to be the most pertinent.

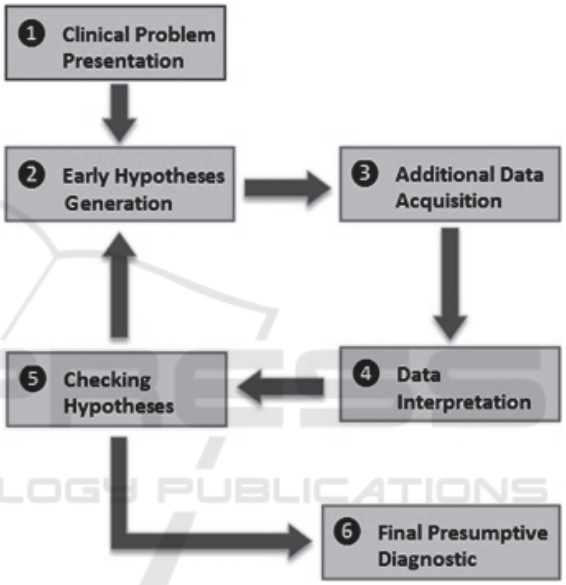

Figure 1: Hypothetical-deductive process of clinical reasoning (Nendaz et al., 2005).

The number of those hypotheses is, generally, comprised between 4 and 5 suggestions. After additional clinical information gathering step, based on the hypotheses proposed before, an interpretation of these data must be carried out to check the compatibility between the additional data and the proposed hypotheses. Such verification allows for an evaluation of the hypotheses that determines if it should be accepted, rejected or reevaluated. It should be noted here that it is quite possible that new hypotheses may be generated and evaluated during the next iterations. Thus the iterative process can proceed through a cycle that will continue while the final diagnosis still not reached (Nendaz et al., 2005; Vanpee, Gillet, & Godin, 2002).

We must understand well that the efficiency of the reasoning process is highly dependent on the

way under which knowledge is structured in the clinician long term memory (Steward et al., 1991).

Indeed, the most significant cognitive studies in this area showed that the clinical cases encountered during clinical experience provide physicians and students with the ability to better structure their knowledge and build pertinent inference networks, which can be unconsciously activated every time they are faced to a new clinical situation (Bordage, 2005; Harasym, Tsai, & Hemmati, 2008). Consequently, the quality of memory knowledge structuring is effectively a key factor that directly impacts on clinicians 'skills and abilities, particularly for students.

Therefore, one notices that a learning method of the medical diagnosis becomes relevant since it allows learners to easily overcome the challenges related to the reasoning process, to effectively structure their knowledge (Chamberland, 2007). Learners collaborate also with others and it seems that it still the most practical used way in their real contextual work as reported by numerous pertinent studies related to such issue (Aarnio et al., 2010; Lerner, Magrane, & Friedman, 2009; Zwarenstein, Goldman, & Reeves, 2009).

Concerning our environment design, we have adopted the analytical approach because it seems to be the most suitable for learners' training while it favors interaction and negotiation between them and thus promotes collaboration to enable social knowledge construction. Indeed, such approach provides for students the opportunity to deal naturally with the reasoning process used by experienced clinicians, while they work together on a common clinical case and manage both construction and structuring of their knowledge. The method may even generate situations of socio-cognitive conflicts that extend the learning process towards social activities as they arise in real clinical settings.

3 ENVIRONMENT PRESENTATION

Our research approach reflects, the socio-constructivist theory point of view, which considers learning as an activity that overcomes the individual scale, and projects it in a larger framework. It is about the social process of knowledge construction, which favors interaction and communication between learners.

As we mentioned it previously, our environment is based on the Hypothetical-deductive process, which is considered as the most effective method in the field of the medical education. Indeed, though this process allows clinical reasoning to be modelled according to a way that is individually used by experienced doctors, we tried in our work to adapt it for distant collaborative learning situations that are based on synchronous interaction. Our approach is intended to favour the social aspect within the learning environments through a set of appropriate tools supporting interaction and negotiation activities as well as learners' points of view confrontation. Our main objective here is to enhance the collaborative reasoning and knowledge co-construction, as well as providing to learners the suitable opportunities to master the most utilized reasoning process in the clinical background.

Access to a remote collaborative learning environment, should be considered across heterogeneous platforms machines. This makes interoperability a fundamental factor in the assessment of the system quality and effectiveness. The web 2.0 concept seems to be the most adequate technical solution to effectively overcome machines incompatibility problems. Taking into account also the excessive keen interest of the current generation of learners for any web technology, it would be injudicious to provide learning assistance models while ignoring such fact. Thus, the technological solution we propose here is designed through a web-based approach. Through such way, we expect to have learners' full commitment while taking part to distance learning sessions and lead them to effectively interact with their peers. Finally, a key factor that also affects learners interactions, concerns the environment external presentation.

Therefore, our preoccupation was obviously to provide a learning environment with an ergonomic easy to use web interface for learners in order to significantly reduce their cognitive loads, and then enable them to focus more on the clinical reasoning and the common case solving.

Through a typical collaborative learning scenario, a clinical problem must be presented to learners as a spontaneous complaint announced by a patient. This complaint is elaborated by the tutor who will supervise the whole problem solving process. We must notice here that the case elaboration should be done by taking into account the tutor's learning objectives that he plans to achieve with learners. Another key factor concerns the problem's complexity degree which must be adapted to learners' skills and work session duration.

Consequently, the suggested environment consists of three workspaces (Figure 2). The first

workspace is intended for the preparation of the clinical case by the tutor, the second one is designed to support collaborative learning sessions and the third one allows learners to review any previous learning session, by replaying different scenarios of the associated clinical solved problems.

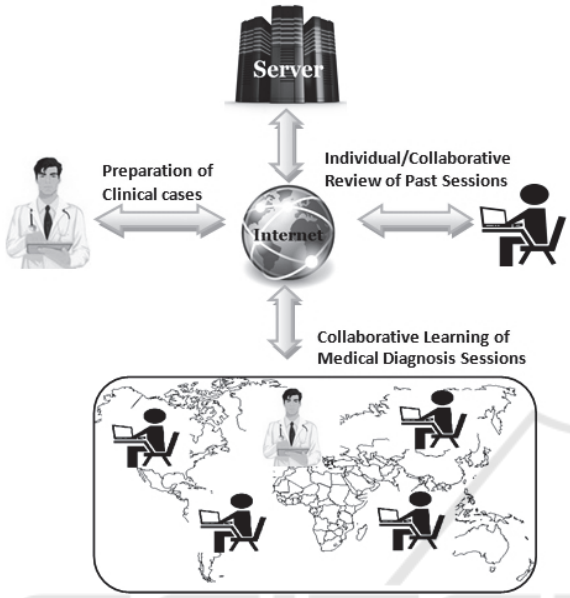

Figure 2: Environment workspaces.

3.1 Clinical Case Elaboration

The first environment's workspace is private and is accessible only to the tutor where he (she) elaborates the clinical case content that will be collaboratively solved by learners under a synchronous mode. We have to remind that learners work on the same case at the same time through a WYSIWIS way (What You See Is What I See), which is a synchronous way of sharing the same view, so the actions performed by one of them are immediately made visible to the others. The case elaboration includes the clinical case presentation, collecting patient's personal information, anamnesis or clinical history, patient's clinical and paraclinical exams related to the case as well as the pertinent related documentation required when solving the problem. We should note that efficiency of the collaborative session depends greatly on the clinical case elaboration. In addition, the tutor has the possibility of adapting or enriching more the studied case as the learning session evolves. The prepared content will be progressively displayed depending on the session's phase and learners' needs. Once a case elaboration is fully completed, the collaborative learning session of the clinical problem solving may be achieved within the second shared workspace, which represents the environment's core and the most significant step of the clinical reasoning training process. Learners can access it through a simple authentication protocol based on the user's login and password. To allow group awareness, each learner's action in the shared workspace is colored by his specific associated color. Such way allows his peers to intuitively identify him (her) within the shared workspace via his contributions. The patient's role is assigned to the tutor, who is considered as the session's facilitator and the main source of the patient's information.

3.2 Medical Diagnosis Collaborative Learning Session

The collaborative learning session comprises three work phases according to the clinical reasoning Hypothetical-deductive process (Figure 1, Sec. 2). In the following paragraphs of this section, we will discuss each phase and bring more details through our environment interface views.

3.2.1 Clinical Problem Representation

The first phase of the session (Figure 3) takes into account the representation of the clinical problem, which constitutes a key step of the whole process. We should note that for the medical community, the direct exploration of the patient's complaint in the clinical problem solving has a negative effect on the reasoning approach as well as on the quality of the suggested diagnosis. It is rather highly required first to look for the most appropriate medical meaning that should be associated to such complaint and then generate what we call semantic axes (man/woman, unilateral/bilateral, acute/chronic) whose medical data are compared and contracted (Bordage, 1999, 2005; Steward et al., 1991).

The resulting semantic transformation called also mental representation of the problem enables optimising the research of pertinent hypotheses in the clinician's memory. Compared to experienced doctors, novices ones generally encounter difficulties when building their mental representation of the met case, this may lead to a random generation of hypotheses and to an uncertain research on clinical data. Consequently, it seems very important to fix the problem's representation as one of the key learning objectives in the clinical background (Bowen, 2006).

In this phase of the session, learners elaborate their own representations of the clinical problem.

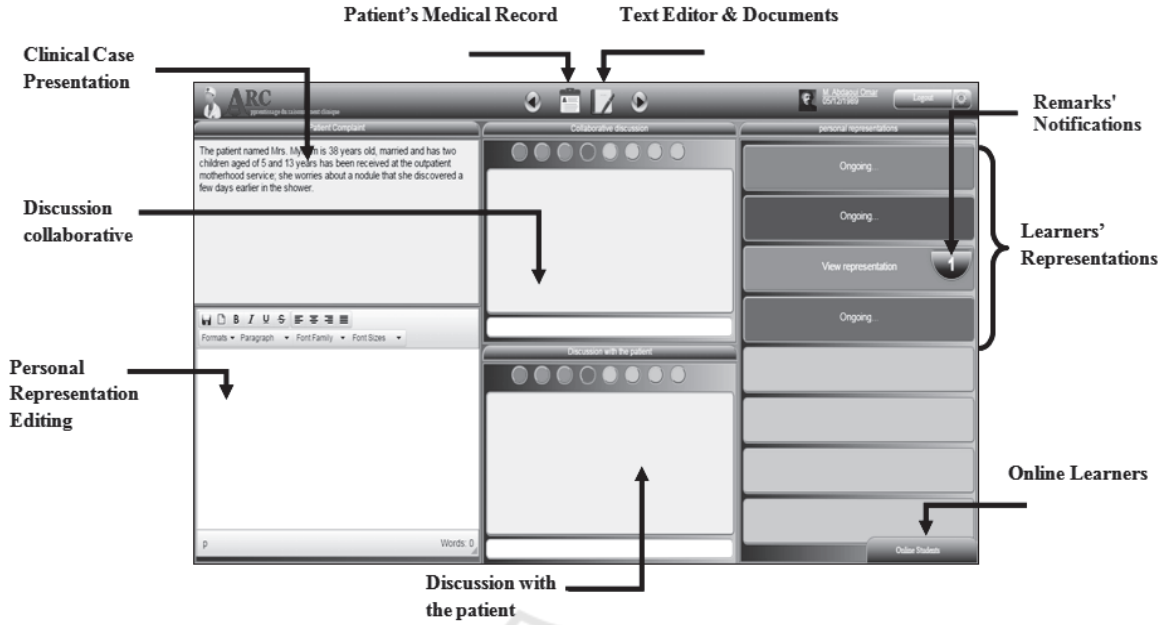

Figure 3: Interface view of the first step of the learning session.

Each learner can visualize the others' representations and leave them comments which will be displayed as notifications. According to these remarks, learners can adjust or correct their representations, and the most agreed one will be selected as the relevant collaborative representation.

Regarding to the patient's medical history, learners can explore a fictive medical patient record to collect any required information for their medical representation. Our shared workspace embeds diverse assistance tools that learners may use. To support communications within the shared workspace, we provided a conversational tool with the patient, and another for collaborative discussions among the group's members. Learners can also access at any time to the documentation recommended and seek assistance from tutors to remove ambiguities or seek clarifications. Finally, to support learners' notes and remarks editing, we have integrated within the shared workspace a shared text editor.

As we have previously indicated, the problem's representation quality has a great impact on the pertinence of the clinical reasoning approach and the correctness of the proposed diagnosis. In our environment, we have provided to learners the opportunity to compare and confront their different representations in order to favour brainstorming activity during clinical reasoning and enable them to significantly improve their skills.

3.2.2 Hypotheses Generation, Filtering and Structuring

The first generation of hypotheses, allows learners to start collecting as much information as possible on the considered case. The following step will be achieved through interactions among learners and lead them to structure the clinical problem and reduce the number of its associated suggestions. Such selection of hypotheses allows learners to optimize their work memory efficiency while useless details don't have to be memorized and overload it, which may have great impact on learners' focusing ability (Nendaz et al., 2005). We note here that the work memory enables keeping short term information in mind, some seconds or minutes, to mentally realize the associated operations.

At the second step of the session, learners can suggest early hypotheses (Figure 4). Each one is displayed with the specific learner's color that has suggested it. It follows then interactions between learners through explicit comments related to these hypotheses which may be added to naturally express learners' diverse points of view.

We notice that with the collaborative learning approach, it is strongly possible that among the generated hypothesises we find many of them that are not suitable for the current case. Consequently, learners should filter them at the beginning before the following steps. Such situation that seems to be

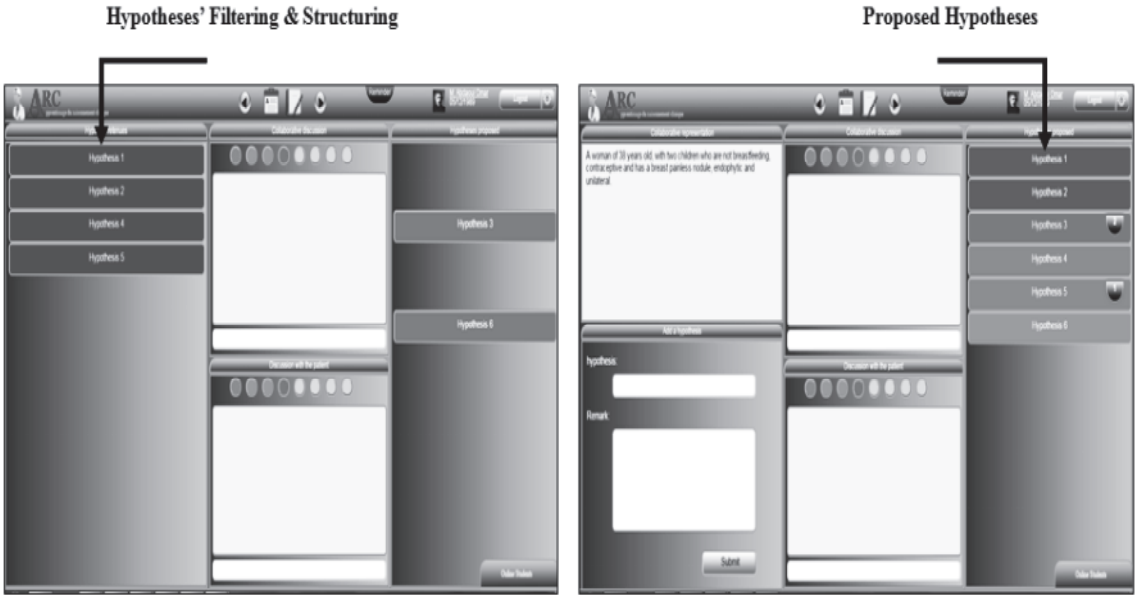

Figure 4: Hypotheses generating, filtering and structuring.

as a constraint is pedagogically interesting. Indeed learners reported that they found it very useful while it generates strong wish for interactions and exchanges between them and enables them by the way to better structure their knowledge. Furthermore, the next step will be easier while learners have only to focus their attention on the most probable hypothesis, which can improve the quality of the problem solving approach.

3.2.3 Additional Information Research and Hypotheses Evaluation

The third step of the session concerns additional information requesting in order to confirm or reject the suggested hypotheses (Figure 5). Such information may be collected through the patient's questioning, signs confirmation and complementary examinations. The requested information will automatically be sent as soon as it is available in the data base. For more pedagogic clarifications, the tutor can ask any requesting learner to motivate his request in order to increase the debate around the question if he deems it relevant. For example, in the case of an imaging diagnostic examination request (scanner, ECG, radio ...) the image will be displayed in a shared window where learners can insert graphic marks or textual comments.

During the hypotheses evaluation step and in case of conflictual situations, learners may use a voting embedded tool to complete filtering them. Any learner has the opportunity to express and motivate his point of view. Through the negotiation process that is fully coordinated within the environment, learners' ideas may dynamically evolve. This is especially intended to enhance learners' skills while providing them with the opportunity to interact within a shared workspace.

Furthermore through awareness features, each hypothesis is displayed with one of these specific colours that explicitly shows its state according to the learners' voting process. Thus, the green color means that most of the learners have agreed the hypothesis; the orange one that few learners among the group have rejected it; and the red one is displayed when it has been rejected by most of them.

The collaborative reasoning process progress may be simultaneously edited by learners through a graphical structure. Such structure is visualized by learners and dynamically evolves during a work session. It allows each learner to evaluate his contributions with regard to the others and adjust them according to the diagnosis evolution. The main goal of the reasoning process graphical structure is to provide as much as possible assistance to learners and enable them to better organize knowledge in their long-term memory. Therefore, they will be predisposed to reuse the acquired knowledge during work session. We notice that at the current state of our research we used a simple graphical structure to facilitate learners' task. However, we plan in the short term to recourse to concept mapping representation which is more suitable while it illustrates the relationships between symptoms and disease related to the treated case.

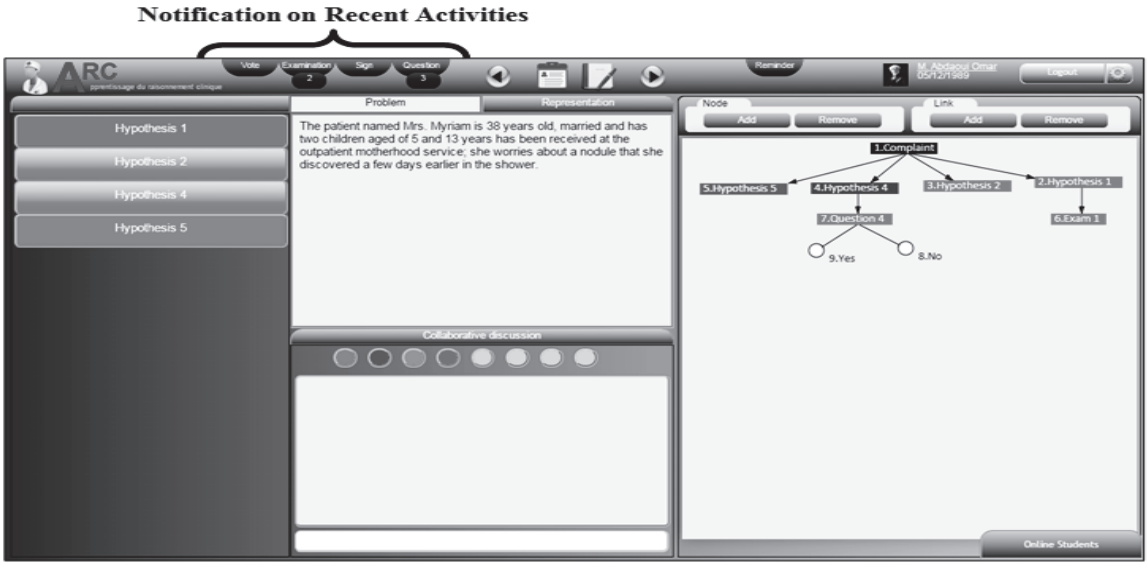

Figure 5: Interface view of the third step of the learning session.

Finally, to model the iterative approach of the hypothetical-deductive method, our environment allows learners to review previous steps of the clinical reasoning process to make changes either on the problem collaborative representation, or on the proposed hypotheses, as new hypotheses can be generated and guide the diagnosis to alternative directions. Furthermore, in order to keep all the participants attention and let them strongly focused, the environment diffuses immediately notifications when new actions are performed by learners. Thus when one clicks a specific notification, a list of shortcuts is displayed to allow direct access to the associated activities areas. We think that through such approach, each learner will have a complete idea about others current activities. For more transparency and coordination within the shared workspace, we also explore reminding notifications that appear when for example a learner proposes a hypothesis or an examination already mentioned before to recall him a redundancy case.

3.3 Individual and Collaborative Review of Previous Learning Sessions

In the classical methods of learning, it is widely recognized that the majority of learners cannot follow and understand the entire session's content, where each of them reaches some level of comprehension and can only improve it during the revision. Thereof, the third section of our environment provides learners with the opportunity of replaying any previous session scenario to fill the gaps. The review session may happen through both individual and collaborative mode and learners can add questions or observations to the session's content.

4 CONCLUSIONS AND FUTURE WORK

In this paper, we have discussed our collaborative web-based environment designed to support medical diagnosis learning and synchronous interaction between learners. Its design aims to favour the professional skills acquiring for medical diagnosis learners, and to enhance collaboration between them.

In order to model a better learning opportunities, we have tried to explore the most pertinent cognitive studies results achieved in the medical education field, that have tackled the hard issue of the clinical reasoning and highlighted the most relevant impacting factors. Finally for the next step of our research work, we plan to elaborate an experimental protocol through our collaboration with our partners at the faculty of medicine. This step will enable us to draw the necessary lessons to improve our design proposition.

ACKNOWLEDGEMENTS

This paper is the result of our collaboration with the medical staff within a gynecology and obstetrics emergency unit at Batna town, which we especially like to thank all of them. We also extend our thanks to the students of the service for their patience and cooperation during this study, and for the fruitful exchange of ideas.

REFERENCES

Aarnio, M., Nieminen, J., Pyörälä, E., & Lindblom-Ylänne, S., 2010. Motivating medical students to learn teamwork skills. *Medical Teacher*, 32(4), e199-e204.

Barrows, H. S., 1980. Problem-based learning: An approach to medical education. Springer Publishing Company.

Bordage, G., 1999. Why did I miss the diagnosis? Some cognitive explanations and educational implications. *Academic Medicine*, 74(10), S138-43.

Bordage, G., 2005. La prise de décision en médecine: quelques mécanismes mentaux et des conseils pratiques. La revue de médecine interne, 26, S14-S17.

Bowen, J. L., 2006. Educational strategies to promote clinical diagnostic reasoning. *New England Journal of Medicine*, 355(21), 2217-2225.

Chamberland, M., 2007. Les séances d'apprentissage du raisonnement clinique (ARC): description de la méthode pédagogique. Université de SHERBROOKE.

Coderre, S., Mandin, H., Harasym, P. H., & Fick, G. H., 2003. Diagnostic reasoning strategies and diagnostic success. *Medical education*, 37(8), 695-703.

Croskerry, P., 2005. The theory and practice of clinical decision-making.*Canadian Journal of Anesthesia/Journal canadien d'anesthésie*, *52*, R1-R8.

Duquerroux, V., 2009. Etude du raisonnement du clinicien expérimenté et de l'étudiant: apports de la psychologie cognitive (Doctoral dissertation).

Edwards, I., Jones, M., Carr, J., Braunack-Mayer, A., & Jensen, G. M., 2004. Clinical reasoning strategies in physical therapy. *Physical therapy*, 84(4), 312-330.

Eva, K. W., 2005. What every teacher needs to know about clinical reasoning.*Medical education*, 39(1), 98-106.

Evans, J. S. B., 2008. Dual-processing accounts of reasoning, judgment, and social cognition. *Annu. Rev. Psychol.*, *59*, 255-278.

Harasym, P. H., Tsai, T. C., & Hemmati, P., 2008. Current trends in developing medical students' critical thinking abilities. *The Kaohsiung journal of medical sciences*, 24(7), 341-355.

Higgs, J., 2008. Clinical reasoning in the health professions. Elsevier Health Sciences.

Lerner, S., Magrane, D., & Friedman, E., 2009. Teaching teamwork in medical education. Mount Sinai Journal of Medicine: *A Journal of Translational and Personalized Medicine*, 76(4), 318-329.

Nendaz, M., Charlin, B., Leblanc, V., & Bordage, G., 2005. Le raisonnement clinique: données issues de la recherche et implications pour l'enseignement. *Pédagogie médicale*, 6(4), 235-254.

Ortega, E. M., Lessard, Y., Burgun, A., & Le Beux, P., 2005, September. Virtu@ I Consult@ tion: an interactive and multimedia environment for remote clinical reasoning learning in cardiology. *In Computers in Cardiology*, 2005 (pp. 829-832). IEEE.

Pelaccia, T., Tardif, J., Triby, E., & Charlin, B., 2011. An analysis of clinical reasoning through a recent and comprehensive approach: the dual-process theory. *Medical education online*, 16.

Pottier, P., & Planchon, B., 2011. Description of the mental processes occurring during clinical reasoning. *La Revue de médecine interne/fondée...* par la Société nationale francaise de médecine interne, 32(6), 383-390.

Quénu-Joiron, C., 2002. Une contribution aux systèmes supports de Formation Médicale Continue à distance et d'apprentissage entre pairs: conception et expérimentation du forum DIACOM (Discussions Interactives à bAse de Cas pour la fOrmation Médicale) (Doctoral dissertation, Université de Picardie Jules Verne).

Steward, D., BORDAGE, G., & LEMIEUX, M., 1991. Semantic structures and diagnostic thinking of experts and novices. *Academic Medicine*, 66(9), S70-S72.

Vanpee, D., Gillet, J. B., & Godin, V., 2002. Séance d'apprentissage au raisonnement clinique: Une méthode potentiellement intéressante pour l'enseignement de la médecine aiguë. *Louvain médical*, 121(10), 425-429.

Zwarenstein, M., Goldman, J., & Reeves, S., 2009. Interprofessional collaboration: effects of practice-based interventions on professional practice and healthcare outcomes. *Cochrane Database Syst Rev*, 3(3).