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Implementation of collaborative learning to enhance problem solving expertise in entropy in high school teaching

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Abstract

Improving problem-solving abilities is a major challenge for teachers generally and mainly in chemistry and physics, as concepts such as entropy requires a lot of work from both students and teachers, who feel powerless to advance in their search for expertise acquisition. In this article, we try to implement a new perspective based on the theoretical model of expertise development; Vygotsky's theory and collaborative learning. We think that didactic researchers and specialists will have to react not only as program engineers but also as social actors able to empower the actors to be autonomous in the learning processes and the problem-solving issues. Team supervises work, in Vygotsky's perspective can help students achieve their proximal zone development. The criterion-referenced theory makes the focus on the criteria to be achieved on the distribution of group norms. Furthermore, historical, ideological and linguistic issues cannot be missed to bring out a comprehensive analysis of didactic problems.

Keywords: Collaborative learning, entropy, didactic, problem solving.

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1. Introduction

Improving problem solving abilities is a major challenge for teachers generally and mainly in chemistry and physics, as concepts such as entropy require a lot of work from both sides, and often students and teachers feel powerless to advance in their search for expertise acquisition, In this article, we try to implement a new perspective based on the theoretical model of expertise development; Vygotsky's theory and collaborative learning.

2. Stages of development expertise

1- The model of Dreyfus and Dreyfus

Stuart Dreyfus (mathematician and systems analyst) and Hubert Dreyfus (Philosopher) have developed a skill's acquisition model based on the study of chess players and airline pilots.

In the acquisition and development of a skill, there are five successive stages.

This process is a reflection of three types of changes:

– shift from abstract principles to the use of past practical experience;
– change of the situation perception situation: as a whole in which only some parts are useful, not an assembly of elements taken here and there

2/The different stages of competence

Stage 1: Novice

Novices have no experience of situations they may face. To inform and enable them to acquire the necessary experience to develop their skills, describe them these situations in terms of objective factors.

Their practice is therefore limited, often manage measurable parameters (weight, temperature,) and apply standard rules independent of context. Therefore, their behaviour is limited and rigid and actions possibly unnecessary or unsuitable.

Stage 2: Beginner

Beginners have faced enough real situations to rate of the significant factors that breed in identical situations. These factors (Dreyfus describes as 'aspect of the situation') include all the general features that can only be identified through previous experiences.

The beginner can formulate principles behind his actions, but different attributes and identified aspects of these principles are all treated with equal importance. But he still lacks skills to prioritise constituent characteristics of these principles.

Stage 3: Competent

The competent nurse works in the same environment for 2 or 3 years. She begins to perceive his actions in terms of goals or long-term plans which it is aware. This plan attributes the required aspects of the present or proposed position which should be considered as the most important and those that can be ignored.

The care plan establishes a perspective and is based on a conscious analysis, abstract and analytical problem.

The competent nurse has not the speed or flexibility of proficient nurse, but she has a sense of control over things and to be able to cope with unforeseen situations if required.

The conscious and deliberate planning helps to gain in organisation and efficiency.

Stage 4: Proficient

The proficient nurse perceives the situation as a whole and not in terms of aspects. The perspective is not reflected but presents itself as based both on experience and recent events.

The proficient nurse learns by experience what typical events are likely to happen in a given situation and how to change what was intended to deal with these events. So she knows that it plans may not be manifested themselves, but experience facilitates its ability to react according to the perceived priorities.

Furthermore, the proficient nurse uses the maxims that guide but are not yet optimal because the maxims reflect the nuances of a situation and can mean one thing or its opposite depending on the situation they apply.

At this stage, the proficient nurse develops a skill called 'early warning signals', i.e., the power to collect deterioration in health status even before the vital signs clarify these changes.

Stage 5: Expert

The expert is able to move from understanding to action without relying on analytical principles (rules, maxims). His extensive experience gives him an intuitive understanding of the situation and allows him to grasp a problem without getting lost in a wide range of solutions and sterile diagnostics. This control is such that force him to pay attention to details, to a model or a formal rule would lead to a deterioration of performance.

Expert Nurse cultivates the notion of 'what is possible'. His interventions are flexible and show a high level of adaptation and competence. (Griffin & Care, 2014)

3. Previous research

Studies have shown that 65%–76% of university education in chemistry are given in the form of lectures. Instructional level has raised three difficulties in this area, it is the transition from theoretical models to describe the microscopic phenomena, this is added to difficulties in the use of the symbolic language.

Authors emphasised that education focuses more on the symbolic aspects at the expense of the links between the macroscopic and microscopic levels. The architecture of courses and practical tutorials and the strength of the representation of the three spheres as compartmentalised (Gabel, 1993 In Houart Mireille and Nathalie Warzee) affect the modelling activity in chemistry according to Tiberghien.

They tried to focus on the microscopic level as a gateway to the mastery of the three levels even though the experiment was on a small scale, 20 secondary students.

Clarifying the levels of speech and the dialectical relationship also seems an appropriate way to avoid confusion among students in chemistry. Some authors have tried to establish the validity of this analysis on a sample of university students.

These authors have declined the representation of logos to attract the attention of students.

Logos designating three levels of knowledge in chemistry as stated by M. and N. Houart Warzee.

Qualitative analysis of the results of this study indicates gaps in the identification of knowledge levels.

The two researchers conclude that emphasis on the microscopic level seems to increase the uptake of key concepts. Explicit knowledge levels while mentioning the interdependence seems to favour the assimilation of key concepts in chemistry.

4. The prospect of collaborative learning

- The theory of item response
- The criterion-referenced evaluation has been proposed as an alternative to the excesses of the standard evaluation based on norm-referenced schemata. In criterion-referenced assessment reference, performance is a target that indicates whether the objective has been achieved. According to Glaser, the performance is on a continuum on an activity to realise concretely while for the other type of evaluation, the group is the reference to define the degree of achievement of educational goals. It is clear that this assessment was denounced as a source of bias for several populations. Its impact was negative on several populations, especially in multicultural contexts. It raised its bias for the poor communities.

Criterion-referenced assessment can be approached in two ways:

a. The ideal criterion-referenced assessment or items closely specify the criterion. In this case, we have a clear and well-defined response pattern
b. The typical criterion-referenced evaluation as a sample of the desired performance. In this type of assessment.

Glaser and Cox stressed the importance of the reference to criterion-referenced assessment to determine the degree of achievement of objectives and its importance to highlight the progress of learners. (Dziuban & Vickery, 1973)

5. The proximal development zone

Vygotsky conceptualises the role of education in making human beings; the central role in Vygotsky's theory of education, in the sense of socially regulated activity and standardised manufacturing of the human. For Vygotsky, education is an essential activity for capacity development.

Vygotsky became the spokesman of active teaching and embodies the break with traditional pedagogy and psychology, social relations are not only a factor in the development of the psyche but they are also ' the source and origin of the development of psychic functions' of the child who 'first appear in a group, and then become psychic functions integrated into the personality' (Vygotsky, 1931a; 1983, pp. 146–147).

6. Collaborative learning

Collaborative learning has been adopted in order to avoid the effects of classical education in high school during the transition to university education. A leading experience was run at ESIEE in Paris. During this transition, students are faced with a challenging academic environment that involves more and more autonomy (Lefebvre & Bureau, 2013, p. 164)

The PACT project

This project was developed at Telecom Paris Tech to students of preparatory classes; the project is based on the concept of motivation as defined by Viau:

A dynamic state that has its origins in the perceptions that a student has of himself and his environment and the incentive to choose an activity to engage in it and commit to it and persevere in its accomplishment to achieve a goal *(quoted in Bertrand et al., 2013)*

As part of this project, the students learn from others and promote values of caring and sharing. Five conditions were put forward to the implementation of this project:

1. The development of a common goal and interdependence;
2. The interaction between the members of the group;
3. Significance of the individual contribution within the group;
4. Interpersonal skill;
5. Review of the approach. (Bertrand et al., 2013)

The PACT project promotes the face interaction between students, half a day at least is devoted to the face-to-face interaction between students in the presence of a mentor. The assessment takes into account individual efforts and the group involvement. This is a bipolar evaluation while ultimately led that project should satisfy two conditions:

1. The success of the pairs' tasks;
2. The completion of tasks by the group.

The project evaluation with students revealed a satisfaction rate of 76% to 83%, teamwork seemed a challenging experience and for 90% of participants, PACT allowed the opportunity to create their own subject. (Bertrand et al., 2013)

7. Methodology

As a chemistry and physics teacher for more than 20 years, I cannot avoid the impact of this experiential background. Consequently, I can't avoid the bias linked to my personal daily life practice as a teacher, my successes and failures as a teacher will colour my perceptions and my conclusions, but we tried our best to respect the requirements of qualitative research. In the beginning, we submit the project to students and workmates and we got the approval for the whole perspective. In fact, we believe that the best way to use the results of the research consists of involving stakeholders. At each step, we submit the research protocol and we improve our research design by the way. To explore learning difficulties and problem-solving issues, we encourage students to speak loudly during the problem-solving processes.

8. The sample

The sample is composed of 15 high secondary school and 12 undergraduate university students.

9. Results and discussion

9.1. Problem solving level

Experts and novices have different strategies to solve problems. For novices, we found a gap between the results found and the basic principles of entropy, even if, they are aware of the theoretical background, the way they call back the general tools doesn't always fit with the problem. We didn't find that discrepancy among experts who were able to take advantage of the theoretical knowledge, they can go back and forth, they didn't hesitate to stop, to ask what way it should be to avoid the *cognitive dissonance.* Doing so, they organise their self-made strategies, they feel comfortable to give their own answers and they didn't look for ready recipes like novices, and generally, they make their road by walk. Like a snowball, every success enhances their self-confidence and make them feel able to solve other problems in a genuine way. Even in case of failure to find a solution, novices don't have clear cut concept understanding, often they can't distinguish between two different concepts: heat and temperature. Novices have difficulties to verbalise the mental processes behind the results found, they are ready to jump on numeric applications to look for fast solutions.

When they fail, they are struck and seem unable to go back to previous knowledge to pick up tools in their search for better outcomes; they are undecided about next steps. Often, they look for external support.

According to Goffard and Dumas-Carre (1993), there is a lack in school programme in teaching problem-solving skills; moreover, students didn't find the link between school learning and problem-solving requirements. Some researchers have tried to reduce that gap by teaching a prescriptive model: instruments guide, tasks. (Goffard & Dumas-Carre, 1993)

9.2. Metacognitive levels

Experts feel they are in control of the problem-solving issues as if they have a toolbox that can be used in need. Moreover, they are selective in their use of the available tools, they have the initiative to change the tools at any time depending on the issues. On the other side, novices anticipate their failure even before trying different options. One student said *it's not easy for me even if I make several trials, I've never succeeded in this matter and I will never do.*

At the attribution level, novices are ready to jump to the conclusion that if they can't solve the problems, *It's not my mistake, it's because they never show me how to do!!*. In fact, I think this is a recurrent issue, students don't have opportunities to develop skills related to problem-solving issues in general and specifically in thermodynamics. Even some teachers feel powerless to introduce certain concepts in entropy. Mentoring practices can be helpful for students who have learning difficulties

10. Curriculum issues

Changes during the last decade have affected the programme structure of chemistry and physics at the high school in Morocco. The fact that new programmes don't include any more thermodynamics courses has an impact on problem-solving skills and learning abilities among undergraduate university students. Without learning background in entropy, students feel overwhelming to the requirements of the thermodynamics course.

Moreover, the transition to the university is a challenging experience for students from a linguistic point of view. As the scientific curricula are still offered in the Arabic language, the students are struggling to understand the French language and then the course content; many students give up the university studies because of the linguistic challenge and they decide to make another vocational choice. The experience we have as a mentor for students facing learning difficulties in thermodynamics allows us to mention that they don't lack abilities to attend, learn and succeed but we think that the structure of the learning practices keeps them isolated as individuals struggling alone. Hence, learning communities made of students and self-run can be a solution to the lack of structures enabling students to overcome learning difficulties. We don't mean that these communities can be totally autonomous but they can be supervised by mentors, teachers and eventually joined by other social specialists.

11. Conclusion

At the end of this article, we are allowed to say that didactic problems are not a technical issue that can be solved by introducing content changes only. In fact, didactic issues are more complex than that. We think that didactic researchers and specialists will have to react as program engineers but also as social actors able to empower the actors to be autonomous in the learning processes and the problem-solving issues. Team supervises work, in Vygotsky's perspective can help students achieve their proximal zone development. The criterion-referenced theory is also another important aspect in our approach, it makes the focus on the criteria to be achieved on the distribution of

group norms. On the other side, historical, ideological and linguistic issues cannot be missed to bring a comprehensive analysis of didactic problems.

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