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Evaluation of Instructional Practices

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Abstract: The evaluation of instructional practices (IPs) is generally a poorly defined process, either in its qualitative or quantitative components. Often, an IP is evaluated by its impact on students' academic success, which is usually measured by students' grades in summative assessment tests. This, however, may be a biased process because, in general, the teacher(s) who conceives(e) the instructional practice also participates(e) in its implementation and in students' final evaluation. Therefore, not always a positive correlation between an instructional practice and students' academic success should be used as an argument to validate the instructional practice. It is nonetheless very advantageous to know the reasons for the success/failure of IPs, as this information is crucial to correct any deficiencies or to improve critical aspects. For this reason, it is essential to assess students' opinion/attitude towards the IPs that are intended to be evaluated. In this work, we describe a methodology for evaluating IPs based on a five-point Likert scale psychometric questionnaire, in which reliability is measured by Cronbach's alpha coefficient. In order to exemplify the application of this IP evaluation methodology, we analyzed a study case of cooperative learning IP implemented in an introductory Physics course, taught at the Department of Physics and Astronomy of the Faculty of Sciences of the University of Porto.

Key words: instructional practice evaluation, psychometric questionnaire, Cronbach's alpha coefficient

1. Introduction

According to Tebabal et al. (2011), the main objective of teaching, at any level of learning, is to achieve a fundamental change in the learner/student. To facilitate the knowledge transmission process, teachers must apply teaching/learning methodologies that best suit the objectives and expected learning outcomes, involving learners in a transformative learning-based methodology (Tebabal et al., 2011).

21st century education requires the development of higher-order skills, such as metacognition, cooperation, creativity, among others (Trilling et al., 2009; Bereiter, 2002; National Research Council, 2000). All learners, regardless of their socioeconomic status or academic background, need equitable access to different opportunities that will allow the development of these skills. In particular, successful learning experiences, focused on higher-order skills (example: metacognition), are extremely important for all students involved, as they help not

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only the improvement of students' academic performance, but also help creating a cycle of continuous social improvement (Becker et al., 2002; Snell et al., 2018). In this field, cooperative instructional methodologies, based on questions and problems, which enhance higher-order competencies, have many benefits for all students, including students with low academic performance (Yang et al., 2019), namely, at the level of deep understanding of the subject taught, the development of critical thinking and self-efficacy (Chan, 2013). Thus, student involvement in a cooperative instructional practice requires:

i) development of metacognitive skills, i.e., skills necessary for setting goals, monitoring and reflecting on the knowledge acquired; metacognition aims at helping learners thinking about their own learning process in a more explicit way (Brown, 1997; Javelvela et al., 2015; National Research Council, 2000). Essentially, metacognition means being aware of what you are thinking about and choosing effective strategies.

ii) social interaction quality (Barron, 2003; Kaendler et al., 2015; Stahl, 2006); learning strategies are usually more effective if taught in cooperative groups so that learners can support each other and make their thinking explicit through discussion.

iii) epistemic changes (Barzilai et al., 2018). Students with low academic performance have several difficulties and fewer opportunities to develop skills in these areas, creating a vicious cycle. However, their involvement in cooperative instructional methodologies allows access to educational opportunities referring to "a state directed towards a goal of active involvement and focused on a learning activity" (D'Mello et al., 2017), which translates into academic success of those involved. However, addressing student needs was identified in the recently published *How People Learn II* report (National Academy of Science, Engineering and Medicine, 2018), as an area that still needs considerable research. As of the beginning of the 20th century, some authors, like Austin (1946) and Wittgenstein (1969), denied that knowledge is a mental state, like, say, consciousness (being in pain, having an opinion, doubting); Austin claimed in his paper "Other Minds" (Austin, 1946) that when one says "I know", it is not a mental state that is being described, though mental states may be involved; it is instead an indication that one is entitled to say that such and such is the case, i.e., that one has the adequate credentials to solve a problem, a question, a doubt. A typical example of such view in a classroom setting is: if a student always gives the right answers to questions and problems related to the topics of a subject, the student is entitled, on this view, to have knowledge of those topics, although student may not be aware that he knows it.

Traditionally, teacher-centered methodologies have been widely used as a way of transmitting knowledge, compared to student-centered methodologies, which are currently in full growth (Hightower et al., 2011). Research on teaching/learning methodologies continues in a constant effort to ascertain the extension and depth of student learning due to different methodologies. Even today, the effectiveness of instructional practices continues to raise issues of considerable interest in the field of educational research (Hightower et al., 2011). The student engaged in a methodology based on cooperative learning is *no longer* a mere *educational consumer*, but rather a transdisciplinary learner deeply involved in self-determination, i.e., he/she participates more actively in educational decision-making, and in the appropriate transformation of his/her academic and social world. Similarly, the teacher "is *no longer* a mere technician charged with administering an *educational commodity*, ... Instead, they (teachers) serve the roles of mediator and companion; they become the enabler of the students' self-determination and social emancipation: teachers as catalysts for transformation. This includes facilitating

emotional intelligence, and critical awareness (critical thinking)" (Hampson et al., n.d., pp. 12–13). In this context, cooperative learning occurs through a constructivist view of knowledge (Vygotsky's Constructivist Learning Theory: Vygotsky, 1978; Daniel et al., 2007), based on the idea that the only meaningful learning is the one which occurs through interaction between the subject, the object and their peers (students or teachers). For Vygotsky, other forms of learning, such as observation, imitation, demonstration or exemplification, are considered secondary. Vygotsky emphasizes the connection between people and the cultural context in which they live and are educated (Ramiro, 2007). According to this author, students use instruments that seek the culture where they are immersed and, among these instruments, language has a prominent place, which is used as a means of mediation between the subject (student) and the social environment. Vygotskian methods also include group/peer learning (Woolfolk A., 2004) as a way of better internalization of new information and knowledge. The internalization of these skills and instruments leads to the acquisition of higher developed thinking skills, constituting the core of the cognitive development process (Ramiro, 2007).

Another view on cognitive development was advanced, around the same time, by Piaget (Piaget, 1950). According to Piaget, the final stage of cognitive development is formal operations, where learners are able to think abstractly. At this stage, learners have achieved skills such as inductive and deductive reasoning abilities (Woolfolk A., 2004), and they have developed hypothetical and complex thinking skills, that will support the identification and solutions of problems in different settings, in particular those faced in classroom. The acquisition of metacognition (thinking about thinking) is also a defining factor of these learners in such formal operations stage, as well as the development of schemes (mental representations). As Piaget stressed, these schemes could be changed through the so-called assimilation (acquired knowledge) and accommodation (adaptation of assimilated knowledge to the perceived one), which could end in a new cognitive stage of learner´s development whenever equilibrium between these two stages occur.

Although Vygotsky' and Piaget' s theories provide important cognitive development views, differences and similarities are ascribed to them. While Piaget stressed the importance of progress through the stages of cognitive development through maturation, discovery, and some social interactions through assimilation and accommodation (Woolfolk, A., 2004), Vygotsky claimed that the cognitive development could be achieved through culture and language, with a promoted guided discovery in the classroom, where students' engagement in learning activities is supported by teacher guidance, i.e., by a scaffolding technique. An example of the importance of such view was provided by Haataja et al. (2019) and Van de Pol et al. (2010), where the former stressed that "scaffolding is a contingent interactive process between the teacher and students. The teacher interprets students' needs for support and fades out its amount and intensity as students' actions and competence allow. Through fading, the teacher's role in problem solving diminishes and the responsibility for the progress is transferred to the students". Different authors, like Alfieri et al. (2011) and Fyfe et al., (2012) also stressed that scaffolding is crucial in collaborative problem-solving learning activities to reach a beneficial learning. In this framework, Vygotsky' s theory principles involve the so-called Zone of Proximal Development (ZPD), defined by Vygotsky (1978) as "the distance between the actual development level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers."

The evaluation of instructional practices is generally a poorly defined process, either in its qualitative or quantitative components. Often, an instructional practice is evaluated through its impact on students' academic success, which is usually measured by the marks they obtain in summative assessments. This framework is,

obviously, prone to biases, given the fact that the teacher(s) who conceives(e) the instructional practice can also participate in its implementation and in students' final evaluation as well. Therefore, not always a positive correlation between an instructional practice and students' academic success should be used as an argument to validate the former.

In this work, we describe a methodology for evaluating instructional practices through psychometric questionnaires based on a Likert-scale (Trochim, 2006), whose reliability was tested by Cronbach's alpha coefficient (Cronbach et al., 2004).

2. Description of the Instructional Practice

We present a study case of an instructional practice of cooperative learning implemented in an introductory Physics course taught at the Department of Physics and Astronomy of the Faculty of Sciences of the University of Porto (FCUP) in the fall 2018. The introductory Physics course combined lectures and seminar classes. In seminar classes (Seixas et al., 2019), students worked in small group, using whiteboards for shared problem solving and presentation (Figure 1). In these classes, brainstorming and critical thinking were promoted, with teacher assuming mediator's role.

Figure 1 Students in Cooperative Whiteboarding Based Seminar Classes

(*Source:* Seminar Teacher M. A. S. Silva)

3. Instructional Practice Evaluation

The objective of this study was to perceive and assess students' attitude and degree of compliance with the use of whiteboarding-based cooperative learning. We also intended to know the reasons for success/failure of the instructional practice, since this information is crucial to correct or improve critical aspects. About 100 fresher students from three undergraduate programmes at FCUP participated in the questionnaire, namely, Environmental Sciences and Technology, Geology and Chemistry.

To evaluate the instructional practice, we adopted a methodology based on psychometric questionnaires (Trochim, 2006). The instrument consisted of classroom observations as tools for data collection and an online survey adapted from the SAGE survey, developed at the Center for Study of Learning and Performance (Quebec, Canada) (Duckworth, 2010). The survey, based on multiple choice questions and entitled "Attitude Towards Cooperative Learning with Whiteboarding in Introductory Physics" (ATCLWIP; Seixas et al., 2019), featured a five-point Likert scale, with the format *strongly disagree, disagree, undecided, agree and strongly agree*. The ATCLWIP survey was made available to students through Moodle platform of the University of Porto and its reliability was assessed using Cronbach's alpha coefficient as described by Seixas et al. (2019). In this survey, "positive interdependence", "individual accountability", "face-to face interaction", "interpersonal and small group social skills" and "group processing" were investigated, as they were considered beneficial for developing students' academic and social learning skills (Gillies, 2007; Kouros et al., 2006).

ATCLWIP survey' s student answers (Seixas et al., 2019) were analyzed statistically, using Excel, through the mean and standard deviation; agreement, undecided and disagreement percentages were calculated as well. The reliability of the questionnaire was tested using Cronbach's alpha coefficient (Seixas et al., 2019).

4. Results, Implications and Recommendations

As asserted by Seixas et al. (2019), answers to the ATCLWIP questionnaire survey, investigated through "positive interdependence", "individual accountability", "face-to face interaction", "interpersonal and small group social skills" and "group processing", elements considered crucial for the development of students' academic and social learning processes, revealed that the implementation of this cooperative methodology contributed to students increase in learning, critical thinking and socialization. In order to verify the reliability of the survey questions, Cronbach's alpha coefficient was calculated for the different items. According to the literature, a reliable scale should present a Cronbach's alpha coefficient with a minimum value of 0.7. The values of Cronbach's alpha coefficient found for the different items showed values equal to or greater than 0.7, with one exception. The item exhibiting a Cronbach's alpha coefficient below 0.7, reflecting scale unreliability, was related with "frustration of group members", and will be analyzed in future again.

5. Conclusion

The statistical analysis of the survey stressed the development of academic and social skills that students have achieved through cooperative learning with whiteboarding in classroom setting. Based on the answers and reflections of students, cooperative group work enhances not only learning and socialization, but also critical thinking, where students can support each other and make their thinking explicit through discussion. The survey also stressed students' willingness to use this practice in other programmes at the university.

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