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The influence of an in-service programme on primary teachers conceptions about practical work

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Abstract

The purpose of this study was to investigate how an in-service programme influenced primary teachers' conceptions about practical work. Ten elementary teachers participated in a Portuguese city in a one-year professional development programme, which aimed to promote the use of practical activities in classroom. Semi-structured interviews and classroom observations were both used to examine changes in teachers' conceptions about science teaching and in their classroom pratices. Data also included written artefacts, such as teachers' written reflections, lesson plans, activity sheets, assessment items and student work samples. Based on the analysis of the data, the changes in teachers' conceptions were organized into four categories: student and learning, teacher and teaching, science teaching, and teaching context. Throughout their participation in the programme, teachers pointed out several constraints related to planning and implementing practical activities. Results indicate that most teachers were able to overcome their initial difficulties and progressively gained more confidence in using student-centered pratices. However, one year after the end of the programme, teachers reported that their actual practices did not changed significantly, particularly with regard to inquiry-based practical and collaborative activities, which remained absent or rare. Implications for professional development and further research are discussed.

Keywords

Teacher conceptions; practical work; primary teachers; professional development.

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La influencia de un programa de formación en las concepciones de profesores de primaria sobre trabajo práctico

Resumen

El propósito de este estudio fue investigar cómo un programa de formación continua influyó en las concepciones de los profesores de primaria sobre las actividades prácticas. Participaron en el estudio diez profesores de primaria de una ciudad portuguesa que asistían a un programa de desarrollo profesional, que promueve el uso de las actividades prácticas. Se utilizaron entrevistas semi-estructuradas, la observación de las clases y artefactos escritos para analizar el cambio en las concepciones y prácticas de los profesores. Con base en el análisis de los datos, los cambios en las concepciones de los profesores se organizaron en cuatro categorías: estudiantes y el aprendizaje, los profesores y la enseñanza, enseñanza de la ciencia y la enseñanza de contexto. Los resultados indican que la mayoría de los profesores eran capaces de superar sus dificultades iniciales y ganaron cada vez más confianza en el uso de prácticas centradas en el alumno. Sin embargo, un año después del final del programa, los profesores informaron que sus prácticas reales no cambiaron significativamente, particularmente con respecto a la utilización de actividades prácticas investigativas y colaborativas, que se mantuvo ausente o rara. Se discuten las implicaciones para el desarrollo profesional y la investigación adicional.

Palabras Clave

Concepciones de profesores; trabajo práctico; profesores de primaria; desarrollo profesional

Introduction

Learning science in primary school has been widely defended in literature over the past decades because it gives children the opportunity to form key concepts, and develop the ability to reason from evidence and "skills that can be used in other domains" (Harlen, 2008, p. 14). Many authors argue that children when involved in practical investigations have higher academic achievement (Metz, 2004; Wilson, Perry, Anderson & Grosshandler, 2012), particularly those from low academic achievement and socioeconomic status (Lee, Hart, Cuevas & Enders, 2004). Nevertheless, practical work, especially inquiry-based instructional strategies, wich are complex, requires a renewed role of the teacher toward a mentor and facilitator of learning (Kim & Tan, 2011). Conducting this type of teaching the teacher encourages students to design and plan their own investigations, to set their own goals, to think for themselves, to collaborate with each other it and to share the results of their investigation. However, the children's answers to open questions can not be predicted and teachers may not know how to handle it (Harlen, 1997).

Predominates in teachers' ideas that primary education comes down essentially to learning to read, write and mathematics (Abell & McDonald, 2006), which results in the near exclusion of science topics of their practices and the predominance of teacher-centered strategies (Harlen, 1997). Haefner and Zembal-Saul (2004) concluded in their study teachers' that teachers engaging in scientific inquiry promotes the development of more appropriate understandings of science and scientific inquiry, and the acceptance of approaches to teaching science that encourage children's questions about science phenomena. Nonetheless, participation in professional development initiatives often does

not have the expected results in terms of change in ideas and practices of teachers, as several studies have shown (Lee et al., 2004; Lotter, Harwood & Bonner, 2007; Lotter, Rushton & Singer, 2013; Yerrick, Parke & Nugent, 1997). The majority of these studies found that teachers reveal many difficulties to change their teaching conceptions consistent with the training programs and promoting practical work in their classrooms. Indeed, teachers' conceptions are highly resistant to change (Pajares, 1992) and when they are incompatible with the principles underlying certain innovations or reforms, changing practices becomes impossible (Levitt, 2001; Thompson, 1992). Recognition of the importance of investigating the teachers' conceptions and how they affect teacher training processes is now widely accepted for several reasons. First, the effects of prior beliefs is crucial for the acquisition of new knowledge (Hashweh; 2003; Korthagen, 2004). Second, teachers rarely have the opportunity to examine, discuss and restructure their beliefs during training courses (Hashweh, 2003; Richardson, 1996). In this sense, the present study analyses the effects of an in-service programme on primary teachers conceptions and practices about practical work.

Practical work in primary education

The learning of science in primary school is crucial to the development of attitudes towards science, by challenging stereotypes about scientists and allowing children to build confidence in their own skills of doing science (Peacock, 2002). As Bóo (1999) stated, when children are engaged in activities in wich they have to test their ideas in a systematic way, to seek and respect the evidence, they learn to not jump hastily to conclusions and became more independent. On the other hand, closed-ended practical activities can lead to loss of self-confidence and anxiety in children for fear of not knowing the right answer. Another benefit of inquiry-based learning is that it stimulates learning in more than on area of the curriculum, such as language, arts and mathematics. Furthermore, communication is encouraged through team work, in which students have the opportunity to exchange ideas, cooperate and develop vocabulary (NRC, 1997).

Constraints perceived by primary teachers, when they promote practical work, are bigger than at any other level of education, because they face a huge lack of resources (Abell & McDonald, 2006), they have underlying negative attitudes towards science, especially physics (Harlen, 1997) and have limited science content and didactic knowledge (Appleton, 2007). Thus, according to Abell and McDonald (2006), the most common science teaching orientations in primary schools are didactic, which "emphasizes the products of science, and textbooks dominate", and active / hands-on orientation, whose "goal is limited to making science fun" (p. 249). The natural curiosity of children in many schools is not fostered, as they are not encouraged to explore their own questions. They are usually involved in activities that have to simply follow instructions from the teacher or a text as if they followed a recipe (Moyer, Hackett & Everett, 2007). Another problem raised by the teachers is the lack of time, which according to Harlen (1992), is related to the assessment of student learning. In fact, several studies (Brand & Moore, 2011; Griffith & Sharmann, 2008; Milner, Sondergeld, Demir, Johnson & Czerniak, 2012) have demonstrated that the examinations focused solely on mathematics and literacy content has also contributed to reinforce the misconception that science is not as important as other contents.

As teachers tend to teach the way they learned (Levitt, 2001), if they never carried out inquiry-based activities on the role of students they will obviously have difficulties in its implementation in the classroom (Fay & Bretz, 2008). Also Anderson (2007) considers that inquiry learning is relatively rare in classrooms due to the fact that many teachers have learned science through more traditional approaches or because they do not understand what it is. Teachers' lack of preparation is more evident in primary schools, where teachers

frequently have a reduced science training, as such, they are unfamiliar with inquiry-based learning (Loucks-Horsley, Love, Stiles, Mundry & Hewson, 2010). Therefore, teachers need support to develop knowledge about science, about the nature of scientifc inquiry and how to conduct inquiry-based instruction, to promote significant change in their pratices. In adition, Caamaño and Corominas (2004) suggest that only training and collaborative work between teachers can transform practical work towards more motivating, creative and effective activities.

These recommendations only recently had been highlighted in the Portuguese educational policies. Given this increasing concern about the importance of practical work in primary school, the Ministry of Education set in motion the *Teacher Training Programme in Experimental Science Teaching*, in order to promote experimental science teaching at this level of education.

Teachers' conceptions

Beliefs about how children learn can profoundly affect teachers' decisions about instructional approaches, as well as the role of the teacher in classroom (Crawford, 2007). These beliefs are deeply ingrained since childhood and remained unchanged even after teacher training (Murphy, Delli & Edwards, 2004). The relationship between conceptions and practices is complex and influenced by external factors, and has implications when implementing a new reform. Indeed, a teacher can not adopt a curriculum if his or her conceptions are not aligned with the philosophy of reform (Levitt, 2001). Even when teachers conceptions match new reform ideas, often the traditional nature of the education system makes it difficult for teachers to change their conceptions and practices (Handal, 2003).

The main obstacle to innovation in science teaching practices in primary schools, as Levitt (2001) argued, are teachers' conceptions. In one hand, because innovations requires moving from teacher-centered approaches, that are culturally rooted, to student-centered approaches. On the other hand, teachers do not value science learning at this level of education (Harlen, 1992). Added to this is the fact that teachers often feel insecure addressing science contents (Appleton, 2007) and face some external constraints. These external factors act as barriers preventing teachers put their beliefs into action, and consequently are often responsible for the inconsistencies between the beliefs and practices (Mansour, 2013). Despite the teaching context hinder the desirable change, according to Korthagen (2004), teachers' knowledge and skills exert a more direct influence on the change process.

Although several investigations have indicated a consistent relationship between teachers' conceptions and their teaching practices (e.g. Anderson, 2015; Crawford, 2007; Lotter et al 2007), others have demonstrated that teachers' conceptions do not necessarily have a direct causal relationship on their actions (e.g. Bryan, 2003; Mansour, 2013; Saad & BouJaoude, 2012). This apparent lack of consensus reaffirms the need to further investigate the nature of the relationship between beliefs and teaching practices and the numerous factors that influence it (Bryan, 2003; Haney, Lumpe, & Czerniak, 2003). Yet more important than discussing the relationship between conceptions and practices, it is essential to understand how change in conceptions may occur (Thompson, 1992).

The little attention given to science learning in the early levels of education (Appleton, 2007; Harlen, 1992) is reflected in the limited number of studies focusing on changing conceptions and practices, in particular concerning practical work (Choi & Ramsey, 2010; Lee et al., 2004; Leonard, Boakes & Moore, 2009). Furthermore, few studies have extended

data collection beyond the conclusion of the in-service programme, which prevents an in-depth analysis of its impact on teachers' conceptions and practices.

Methodology

This study used an multiple case design with crosscase in-depth analysis of ten primary teachers' conceptions about practical work during and after an in-service experience (Yin, 2003). All participants were female with a teaching experience between 15 and 31 years. From these ten teachers, one teacher (T1 – all teacher names have been replaced with codes) worked in an urban school in a Portuguese city and the other nine teachers (T2, T3, T4, T5, T6, T7, T8, T9 and T10) worked in rural schools on the outskirts. For these teachers, attending *Teacher Training Programme in Experimental Science Teaching*, was their first experience with professional development programs on science education. Moreover, teachers revealed they had no previous experience with practical work during their preservice teacher education.

Training sessions (plenary, group and classroom sessions) contents were structured by the national programme coordinators, who had determined thirteen collaborative group-work training sessions divided into three phases, over a year. Each phase corresponds to three instructional units – Floating objects in liquids; Seeds and Plants; Dissolving in Liquids. All instructional materials, which included teachers' guides and student booklets, were developed by the national programme coordinators and published by the Ministry of Education. The teachers' guide provide suggestions about how to implement inquiry-based practical work with students, extensive science background information on each content, assessment activities and detailed aswers to the questions posed in student booklets.

The sessions began with a plenary session, which brought together all groups of the in-service programme in that region, and focused on familiarizing teachers with the objetives of the programme. Each session had a duration of three hours. The first group session focused on practical work and inquiry-based learning. Over the following three sessions teachers had the opportunity to carry out some hands-on activities from the first unit and then discussed ways to conduct those activities with their students. After this teachers' had to implement one practical ativity in their classes. The first phase ends with a session to discuss and share experiences arised during classroom implementation. The next two phases continued with the same structure. At the final session (plenary) of the programme, some teachers from each training groups presented the work developded in their classes and reflected about the benefits and constraints of implementing inquiry-based practical work in primary school, including the effect on student progress.

In order to detect changes in conceptions about teaching science and practical work it was used a semistructured interview. This technique is considered essentialbbecause conceptions are not directly observable; they can only be inferred from the teachers' behaviors (Pajares, 1992). Teachers were interviewed before attending the in-service programme and year after it conclusion. After the analysis of the first interview transcripts, it was considered important to understand how teachers argumente evolved throughout the programme, so it was decided to interview all participants at the end of each classroom observation.

Apart from the interviews, it was also taken into account in the data analysis, written artefacts, such as teachers' written reflections, requested in some training sessions, and teacters' portfolios, which included written reflections, lesson plans, activity sheets, assessment ítems and student work samples.

Classroom observations served three purposes. First, according to Fang (1996), sometimes teachers' have a tendency to describe what they think should happen and not what actually happens in the classroom, therefore data triangulation will contribute to understand the complex relationship between beliefs, practices and school context. Second, the information gathered during classroom observations helped to identify teachers' conceptions and interview responses became more meaningful because they were connected to actual classroom episodes. Third, researcher field notes and transcripts from audiotapes taken during classroom observations allowed to describe how teachers' enactment of inquiry-based practical work varied with their conceptions and how it has evolved.

Through the constant comparative method (Strauss & Corbin, 1998), interview and observation transcripts and writen reflections, for each teacher, were analysed and a set of categories and subcategories emerged.

Table 1.

Teachers' conceptions about science teaching and learning

Categories	**Subcategories**
Student and learning	Role of the student
	Individual/collaborative learning
Teacher and teaching	Role of the teacher
	Planning of teaching
Science teaching	Purposes of teaching science
	Teaching strategies
	Practical work
	Assessment
Context of teaching	Students' motivation and abilities
	School constraints
	Education system

The segments extracted from data reflect the thoughts of the participants about the teaching and learning of science. These thoughts are the arguments expressed by the teachers, as Halpern (2013) stated "an argument consists of one or more statements that are used to provide support for a conclusion" (p. 233). So argument corresponds to representations of knowledge, beliefs, ideas and interpretations about science teaching and learning (Sternberg, 2012). The arguments expressed by the teachers reveal conceptual stability when there no are changes in teachers' conceptions about science teaching and practical work. And when there is argumentative instability due to omission or enunciation of new arguments, this indicates that changes in conceptions may have ocurred.

Before participating in the programme, most of the teachers valued a passive role of the student, student individual work and direct knowledge transmission. However, some teachers expressed arguments that encompass opposing perspectives. For instances, T5 emphasized the active role of the students in the learning process, when pointed out that the most interesting activities for students have to involve "practical work and in all areas, from construction, to touch, to shape, to build and to see things happening. The dull things, only in very short periods". But she contradicts herself comes in contradiction by admitting that the few activities she implements, boils down to demonstrations. After participating in the programme, there were no significant changes in the arguments presented by T1, T4, T9 and T10. But, except T4, teachers revealed an increase in the appreciation of an active role of the student and of collaborative work.

When it comes to the role of the teacher, T3, T5 and T8 used arguments that, once again, seem contradictory, they exposed ideas consistent a transmission teaching perspective and after the programme they seem to value teacher's role as facilitator of student learning. For example, T3 referred several times expressions like "expose any theme" and "giving a subject, expose", emphasizing the role of the teacher as a transmitter of conceptual knowledge. However, she attempted to move away from this position when she stated: "I remember my teacher who merely exposed the contents, there was no experiments or group work. Now it's a lot less rigid". Most of the teachers changed their arguments after the programme, except T4, which kept a teacher-centered intruction. Regarding planning of teaching, after the programme, except T1, all participants maintain that they plan their lessons only taking into account the textbook.

Before the programme, teachers listed teaching purposes focused on the acquisition of scientific knowledge and practical work. T1, T2, T3, T6 and T9 also mentioned the involvement of students in the learning process. After the programme, teachers increased considerably the number and diversity of highlighted purposes. In fact, T6 and T9 refered the relationship of scientific subjects with real-world problems, as T6 stated that students need to have "conscience of what is science and how is intertwined with every aspect of everyday life". T10 added: "promote the investigative and scientific spirit in children so that they observe, make predictions and based these predictions on experimentation, and conclusions". T1 also pointed out that science learning enhances interdisciplinary and collaborative work.

Arguments initially expressed by teachers, concerning teaching strategies, are consistent with those listed in the previous subcategory. In fact, teachers highlighted teacher-centered strategies, such as lectures, exercises and practical demonstrations. After the programme, were set out arguments that indicated an increased appreciation of students-centered activities. Though, T3, T5 and T8 still valued highly structured and non collaborative activities.

All teachers, before the programme, presented practical work benefits focused on the acquisition of scientific knowledge, and encourages students' motivation and interest toward science. During the programme, arguments expressed by teachers in their written reflections have diversified, including aspects such as: "group work promotes interpersonal relationships and acceptance of diverse points of view" (T1). Other benefits were mentioned, in particular the development of procedural, attitude and communication skills. In this respect, T6 considered as main benefits of inquiry-based practical work:

> the knowledge that students will get and every step of the process you have to go through to get to it (questioning, structure and activity materials needed, record,

share opinions with colleagues, get to the answer to question-problem and check the differences in what they thought initially).

Some teachers, during and after the programme, mentioned that inquiry-based activities also develops reading, writing and mathematics skills. In short, T4, T7 and T10 have not altered significantly their arguments while in the case of T1, T2, T6 and T9 there has been a progressive increase in the number of benefits associated with practical work. T3, T5 and T8 increased considerably the number of arguments during the programme, but one year later the number of arguments were similiar than those expressed initially.

When it comes to constraints affecting teachers' enactment of practical work, not related to the context of teaching, the highest change in teachers' arguments was recorded in cases of T1, T2 and T6. Initially, these teachers have expressed their discomfort in taking on a new role in the classroom and addressing science contents with their students. Later, they have felt that the only restriction is the excessive teacher guidance. In this respect, T6 mentioned in the interview: "If the investigation is very limited by the teacher, saying, writing all the steps and sometimes even giving the answers, this will not allow the student to explore and learn for themselves...".

Regarding how to organize practical work, it was found that the change in teachers' arguments was very similar to that found in its benefits. For example, participants who further increased the number of benefits were the same that move from believing in highly-structured practical activities toward inquiry oriented activities involving discussion among students.

The analysis of the arguments exposed by the teachers pointed out few changes about assessment, especially when compared with the results obtained in the other subcategories. T1, T2, T3 and T10 made some changes in their arguments toward a learning-oriented assessment. However, the majority continue to use assessment strategies focused on scientific knowledge and teachers attitudes. An example of this is the case of T8 that, during the programme, referred diferent assessment techniques demonstrating commitment to the programme goals, but one year later again refered only instruments used to assess students' knowledge of science facts.

All teachers initially highlighted aspects which affect their enactment of practical work related to the context of teaching, especially with regard to material resources. T3 mentioned that: "sometimes I wish I could use certain experiments but there's a lack of material and I give up". T1 added: "sometimes the cost, because we still have to pay the material." Except T1, all participants taught in rural schools with no more than three teachers, but only T3 considered this was a limitation, she wishes to "have a group to work with, to share ideas. I'm a bit isolated". After the programme, these arguments have lost intensity, only T10 and T4 kept their initial opinion. These teachers assumed that during the following year they have not implemented a single practical activity, in this respect T4 argued that: "we don't have the materials, even with the arrival of some materials to school, we have no place for them. We don't have specific or equipped classrooms, we have nothing…"

Related to the constraints of the educational system, few arguments were expressed by the participants and just T4 revealed conceptual stability. The lack of time to adress all subjects was the most referred aspect. T3, T4, T5, T8, T9 and T10 had more than one grade in class, but only the first and the last did not consider it an obstacle to the enactment of practical activities. T1, T9 and T10 also highlighted students' behaviour and interest as constraints. T1 added students' age as a limiting factor. Interviewed a year later, on this

aspect, replied: "last year I was not comfortable enacting practical investigations with first graders, but now I think that it was perfectly appropriate for them. "

Change in teachers' conceptions was more evident in a group of teachers, headed by T1, followed by T2, T6 and T9. T3, T5 and T8 despite acknowledging several benefits of practical work and a more active role of the students, continued to prefer traditional textbooks activities. T4 stood out from the remaining because her teaching conceptions seemeed unchanged and far away from the principles of the programme. One year later, she even admitted that science learning "is less important, we always give priority to language and mathematics teaching. The subjects don´t have the same importance, under the circumstances". This statement also revealed that science contents are less taken into account when teachers grade their students. In addition, T4 also pointed out systematically the lack of material in schools. Her arguments are questionable, because she taught at the same school as T2 and T6, and these teachers showed an opposite attitude toward science teachinh.

The results also enabled to characterize the practical work implemented by the participants. T1 developed more practical activities than any other teacher, and quite opposite T4 was the teacher who implemented more structured activities, demonstrating congruence with her traditional conceptions. It was also found that most of the teachers initially choosed recipe type activities, but gradually they increased inquiry orientation. Despite this apparent change, in most cases the type of practical work teachers developed with their students remained not aligned with the programme recommendations, regarding the autonomy conferred to students. For instance, except T5 in a single activity, teachers never allowed students to formulate their own questions to investigate. Also other features of inquiry were almost always defined or elaborated by the teachers, in particular: planning procedures, data analysis and conclusions. The students' difficulties often resulted from inadequate planning of tasks, and, in the some cases, the lack of guidance from the teacher. So, quite often, at the end of the activity, often at the end of the activity, many doubts regarding the contents, persisted in children.

Discussion and conclusions

In this study, the teacher (T1) who exhibited a more significant change in conceptions aligned with the in-service programme goals, was also the one who have promote practical activities more frequently and have demonstrated that she continues to implement this instructional approach in classroom. Despite the changes in different components of conceptions, from the start of her participation in the research, T1 advocated firmly the active role of the student. The stability in this argument suggests that this is a core belief in her belief system. However, her convictions didn't reflect in her practices before the programme, once the practical work was practically absent and was limited to recipe type activities. Consistent with Thompson's ideas (1992), T1 justified her prior actions with the lack of skills and knowledge, and "above all confidence" in teaching science content.

The teacher (T4) that least modified her arguments admitted she was forced by the school administration to enroll in this in-service programme, which may be the cause of ther her resistance to introduce changes in practices that were opposite to her beliefs, interests, and motivations (Lee et al., 2004). Indeed, data analysis has showned, unsurprisingly, that was this teacher who presented more problems during the implementation of the practical work. T4 often proved unable to guide the students during inqiry tasks and help them overcoming their difficulties, and her main concern was to keep students under her control. Classroom observations and the interview that took place one year after the end of the

programme confirmed consistency between conceptions and practices. Despite admitting that practical work can be accomplished with simple materials and even after schools received materials fianced by the programme, the majority of participants, in particular T4, continue to consider that the lack of resources is a great barrier. Which seems to indicate that the use of practical work is more strongly associated with beliefs that are not dependent on the context of teaching (Wallace Kang, 2004), aspect that needs further research in the future. The lack of significant change in teachers actual instructional practices points out to the prevalence of certain beliefs, namely: the limited capacity of the students (Wallace & Kang, 2004), the need to control the students for knowledge transmission, that teaching science was not a priority subject (Kim & Tan, 2011), and that practical work serves only to motivate and entertain students (Ireland, Watters, Brownlee & Lupton, 2012).

Apparent changes in theachers' arguments throughout the research, indicated changes in conceptions about teaching. However, quite the opposite, similar to the results obtained by Yerrick et al. (1997), teachers seem to embrace of the ideas advocated by the programme yet without changing their fundamental views about teaching and learning. Nonetheless, it should be stressed that this program promotes a type of instructional practices that teachers didn't have the chance to try as students. The results of this study also demonstrated that the initial conceptions of one group of participants were more aligned with the philosophy of the programme, while teachers who evidenced more traditional conceptions made few substancial changes in their instruction, which is in agreement to the results obtained in other studies (Blanchard et al., 2009; Lotter et al., 2007, 2013). Teachers that are more receptive to innovations are the ones that implement more student-centered practical activities.

There are two important implications for teacher education. Firstly, a professional development programme with a duration of 63 hours may not be enough to overcome the limited knowledge that primary teachers have about of science content and science teaching (Abrahams, Reiss & Sharpe, 2014) and to sucessfully change their beliefs and practices toward science teaching and inquiry orientation (Lumpe, Czerniak, Haney Beltyukova, 2012). Secondly, the study seems to point out that teachers' collaborative work had a positive effect on teachers' conceptions and practices, as it is advocated by Meirink, Meijer, Verloop and Bergen (2009). The collective participation of teachers from the same school in professional development iniciatives allows teachers to develop common goals, share teaching materials, and exchange ideas and experiences arising from a common context, will reduce their reluctance to adopt student-centered inquiry-based teaching (Lee et al., 2004; Lotter et al., 2013).

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