

Designing a web-based constructivist learning environment

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The constructivist learning environment was designed on three perspectives: pedagogical, social and technological. A group of 24 trainee teachers used the environment and participated in the formative evaluation. Results showed that the trainee teachers liked the design specifications and perceived the learning environment to be useful. The purpose of this paper is to describe the design specifications, implementation processes and formative evaluation results of the learning environment. Issues and implications for designing web-based learning environments are discussed.

Keywords: constructivist learning environment; pedagogical design; social design; technological design

Introduction

Constructivist learning environments (CLEs) are often defined as technology-based spaces in which students ‘explore, experiment, construct, converse and reflect on what they are doing so that they learn from their experiences’ (Jonassen, Peck, & Wilson, 1999, p. 194). Compared with traditional instructional settings that are largely teacher-centred, CLEs have numerous advantages, such as more student-centred, collaborative learning, engaging and reflective (Jonassen, Peck, & Wilson, 1999; Sherman & Kurshan, 2005). These advantages, however, do not happen spontaneously unless the learning environments are thoughtfully designed.

The design of CLEs faces many challenges. Traditional design models, such as the generic ADDIE (analysis, design, development, implementation and evaluation) model are most likely to be inappropriate for designing CLEs as the assumptions and design activities of constructivist learning are different from those of traditional instruction (cf. Jonassen & Rohrer-Murphy, 1999). Furthermore, although a number of constructivist design models, such as the R2D2 (reflective, recursive design and development) model (Willis & Wright, 2000) and the activity theory framework (Jonassen & Rohrer-Murphy, 1999) can be found in literature, very few empirical studies have demonstrated how concrete samples have been developed and implemented in practice or how students and teachers have reacted to the learning environments.

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In this study we designed a CLE which involved pedagogical, social and technological elements. The purpose of this paper is to describe the design specification and implementation processes of this CLE and its formative evaluation results.

Conceptual framework

An education system is a unique combination of pedagogical, social and technological components (Kirschner, Strijbos, Kreijns, & Beers, 2004). This section will elaborate on these elements.

Pedagogical

It is critical to distinguish a learning environment from other networked communities, such as an alumni community or a football fan community. The pedagogical component primarily reflects the educational purposes of a learning environment.

The pedagogical design of a CLE must enable students to construct knowledge and hence achieve learning objectives. According to constructivist learning theories knowledge is actively constructed by learners based on their prior experiences, rather than directly delivered by the teacher. Learners are active knowledge constructors, rather than passive information receivers (Jonassen, 1991; Merrill, 1991). Moreover, cognitive constructivists claim that learners are most likely to construct knowledge individually dependent on their personal experiences and newly obtained information. Knowledge construction is a process of internalization and reconstruction of external reality, in which individual interaction with the content plays a vital role (cf. Perkins, 1993).

The pedagogical design of a CLE must: (i) support and satisfy learners' various needs and learning intentions; (ii) be flexible with regard to the learning content and objectives; (iii) involve learning resources and activities that support active learning (Chen, 2003; Kirschner et al., 2004).

Social

People naturally live and work in various communities, in which they turn to others for help when they encounter problems (Jonassen et al., 1999; Wilson & Lowry, 2000). The social dimension of learning has become an integral part of many recent web-based learning environments (Moallem, 2003). The social design of a CLE aims to provide and maintain a friendly and interactive environment in which learners feel safe and comfortable and able to interact with one another (Anderson, 2004; White, 2004).

In contrast to cognitive constructivism, social constructivists argue that knowledge is the outcome of collaborative construction in a social-cultural context mediated by discourse. Learning is a social process in which learners collaboratively construct knowledge through interactive processes of information sharing, negotiation and modification (Gunawardena, Lowe, & Abderson, 1997).

In order to promote social knowledge construction a learning environment must provide a variety of communication tools, such as synchronous (chat rooms and video conferencing) or asynchronous (discussion forums and email) facilities. Moderation by

facilitators is also critical for successful online discussions and social knowledge construction. Effective moderation includes setting up ground norms, encouraging participation, monitoring progress and providing information (cf. Hootstein, 2002; Salmon, 2004).

Technological

A web-based learning environment certainly involves a technological element, as the majority of learning activities are conducted through the medium of the computer. Availability of and easy access to a learning environment are initial requirements, as an effective web-based learning environment must support anytime, anywhere learning (Salmon, 2004). Moreover, interface design is critical, as it determines the usability of the learning environment. Interface design should focus on ease of learning, ease of use and aesthetics (Wang & Cheung, 2003).

Constructivist learning is certainly not reserved for high-tech, multimedia or problem-based learning (Wilson & Lowry, 2000). It happens constantly in traditional classroom settings. The rapid development of ICT, however, has provided a strong technical platform that makes constructivist learning via the Internet more feasible and easier to implement. Although technology is not a panacea for solving all educational problems, it is 'certainly a useful tool that enables us to link various learning communities together in new and different ways' (Taylor, 2000, p. 4).

Design of the learning environment

Course description

This constructivist learning environment was designed for a course entitled 'Constructive learning with the Internet', which was an elective module offered to pre-service teachers in Singapore who held university degrees but were seeking additional educational diplomas. They would be teaching at secondary schools after one year's study at the National Institute of Education (NIE). Primarily the course expected these trainee teachers to develop a knowledge of constructivist learning. They should also be able to apply their knowledge to web-based CLE development.

This course was offered several times in the NIE. Previously it had been delivered by a traditional approach. In each lesson the instructor first gave a presentation on a topic, after which the students were given hands-on experience of developing a web-based learning environment, which was a major assignment on this course. The learning management system Blackboard was used to make announcements, upload course documents and conduct online discussions. The instructor felt that this instructional approach was 'absurd', because constructivist learning theories were being delivered in a largely traditional way. Additionally, the students complained that they lacked concrete examples from which to gain experience of how teachers could carry out constructive learning in authentic contexts.

In the July 2005 semester when this study was conducted the course was implemented using a different approach. The trainee teachers were divided into small groups, with each group being in charge of one or two topics. During each lesson no more than two groups (depending on how many groups chose this topic) gave presentation(s) on the topic, after which each presentation group member led a seminar to further discuss issues on or questions about the topic just presented.

Additionally, each presentation group member submitted an individual report on the seminar discussions by the following lesson. Moreover, each trainee teacher was required to write an individual reflection on what she/he had learned from the presentation(s) and the seminar discussions attended.

This course involved 12 sessions of 2 hours each, running twice a week and lasting for six weeks. Each session covered one topic. In order to give the trainee teachers enough time to study the topics and prepare presentations, the first three topics were delivered by the instructor as usual, with the fourth session being online without face-to-face activities. The trainee teachers prepared presentations on the remaining eight topics from the fifth session on.

A total of 24 trainee teachers (10 males and 14 females) were enrolled on the course. Their average age was approximately 24. Eight groups of three trainee teachers each were formed. Due to the trainee teachers specializations being in various subject areas, such as Chinese, English and biology, two groups included trainee teachers from various subject areas.

The trainee teachers were assessed on the following assignments: (1) topic study (40%), including group collaboration, presentations and seminar discussions and reports; (2) the final project (40%), which involved designing a web-based student-centred learning environment; (3) reflection (10%); (4) online discussions (10%).

The learning management system Moodle was chosen as the platform to host the learning environment, because Moodle has most of the features of other commercial learning management systems such as Blackboard and WebCT but is free of charge. Thus the trainee teachers could continue to use the Moodle system to create new courses in the future, even though their schools had no other learning management systems.

Design specifications of the learning environment

The detailed design specifications of the learning environment are to be described in pedagogical, social and technological aspects.

Pedagogical

The learning objectives and activities were decided through negotiation with the trainee teachers. As it was unsuitable for those groups that were composed of trainee teachers of various subjects to design subject-based learning environments, all groups were given two options: (i) to select two different topics to study; (ii) to choose one topic only plus an extra final project. The groups that chose to give the first few presentations were given bonus points (from 5 to 1), as they had a shorter time to prepare.

The instructor suggested between two and five reading materials for each topic. These suggested materials provided a starting point for the topic. The trainee teachers were expected to explore and use other materials as well. Moreover, to maintain a reciprocal relationship between the learning environment and its members and also make the learning environment more sustainable, the trainee teachers were encouraged to add more resources to share with other group members (cf. Kirschner et al., 2004).

Each student was required to write online reflections at the end of a topic to think further about what they had learned, what issues remained unclear and how to apply the knowledge in other similar situations.

Social

The social design of the learning environment focused on student interaction with other group members, the whole class and the instructor. In order to promote social interaction the following specifications were incorporated into the learning environment.

It encouraged group work. Each group was provided with a group sharing corner, in which group members could share information, discuss questions and work on their presentation files.

It had seminar rooms for online discussions. Topic presenters decided on the way the seminar would be conducted: face-to-face or online. The seminar rooms allowed discussion groups to chat with one another in real time. The instructor assigned trainee teachers to different groups before each lesson.

It involved a Q/A forum, in which the trainee teachers could post general questions, answers or comments regarding the course design, assignments or the assessment. Through this forum the instructor could also determine the learners' problems and concerns. Moreover, the instructor did not need to answer learners' inquiries repeatedly if the questions had been answered before (cf. Lai, 2004).

It supported asynchronous online discussions. The fourth session of the course was designed as an online lesson. During that lesson the trainee teachers were not present in the computer laboratory for their tutorial. They studied the lesson materials and participated in online discussions at any time before the following session. The whole class took part in the online discussions as one group.

Technological

The Moodle system was installed on a computer server located off the NIE campus to simulate as much as possible a real online learning environment. Student accounts had been created before the first lesson. The computers in the laboratory had fast Internet access.

The Moodle system is quite easy to learn and to use. The internal Help section is informative as well. However, relevant resources on the Internet or in books are scarce.

The Moodle system is user friendly. It allows users to customize the interface by reallocating the positions of system components such as messages, upcoming events and recent activities. Users can also update their profiles, including photos or email addresses.

The trainee teachers were encouraged to contact the instructor whenever they needed support. The instructor's contact information was kept at the top of the home page. Additionally, the instructor promised to visit the learning environment regularly, at least twice a day. Figure 1 shows the home page of the learning environment.

Evaluation of the learning environment

Evaluation questions and instruments

The formative evaluation investigated use of the learning environment and perceived usefulness. It aimed to answer the following questions.

- (1) How did the trainee teachers use this learning environment?
- (2) What was the perceived usefulness of the learning environment?

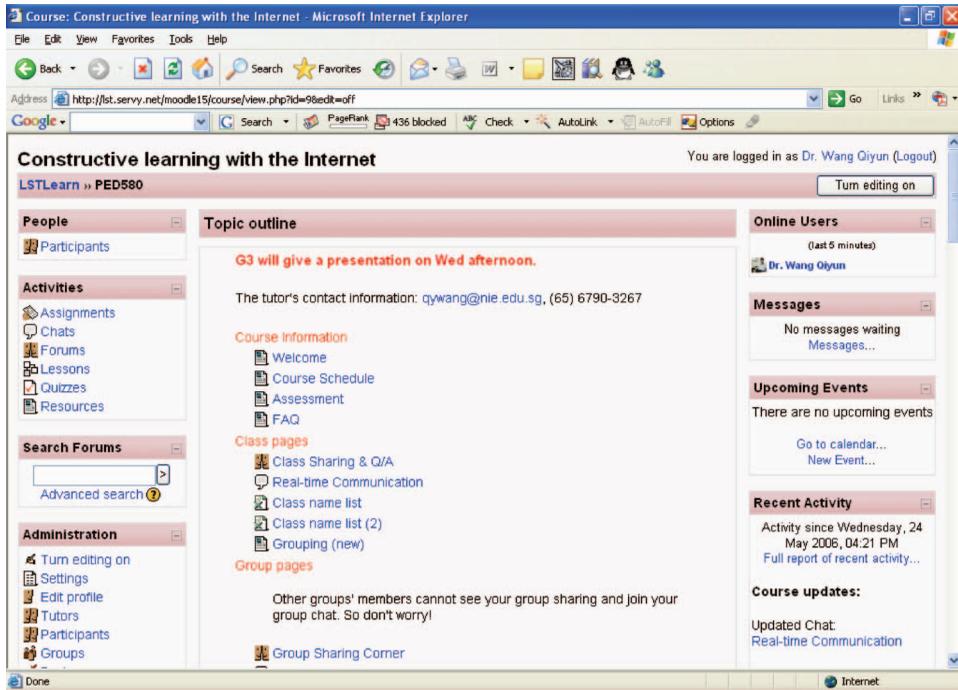


Figure 1. The home page of the learning environment.

Specifically, the first evaluation question aimed to find out how the trainee teachers reacted to the pedagogical, social and technological design specifications of the learning environment, including what happened when they were using this environment, what problems they met and what expectations they had. The second evaluation question attempted to examine to what extent the trainee teachers perceived the learning environment to be useful. Kirschner et al. (2004) claimed that a useful system must fulfil two fundamental requirements. First, it must have the expected functionalities. For instance, a useful mobile phone must have the function of enabling people to talk to another. Second, it must be usable. If the mobile phone has terrific features but is hard to use, few people would want to use it. In this paper the functionalities of this learning environment refer to the pedagogical and social features, while usability refers to the technological aspect.

For the first evaluation question observational notes and online postings were used as instruments to collect data. During each lesson the instructor, who was also the researcher, took notes on activities, questions and feedback. These observational notes recorded how the trainee teachers used this learning environment. Additionally, the trainee teachers also posted a number of messages to the group sharing corners, Q/A forum, seminar rooms or online reflection logs. These postings captured their learning processes as well as concerns.

For the second evaluation question an online survey was administered to all participants at the end of the last lesson. The survey included 20 five-point (strongly agree, agree, neutral, disagree, strongly disagree) Likert scale questions covering the pedagogical, social and technological design. One open-ended question was included to collect further comments and suggestions. All participants took approximately 15 minutes to complete the survey.

Evaluation results

Pedagogical design

In the first lesson, when the trainee teachers were asked to choose topics, several groups chose the same topics, as these topics looked easier or were more familiar to them. The instructor had to intercede to ensure that each group focused on a different topic.

The trainee teachers found the flexibility feature involved in this learning environment useful. Initially five groups chose two topics and the other three groups decided to study one topic plus the final project. After completing the first topic one of the five groups changed their mind, choosing to study one topic plus the final project, as they realized the study topic was not that easy.

The trainee teachers primarily relied on the suggested reading materials to study the topics. In the group sharing corners group members basically shared and discussed issues introduced by the suggested materials. Their group presentations were also mainly based on these resources. Nevertheless, most groups used extra information resources and added resources to the group sharing corners.

The trainee teachers were given 10 minutes to write online reflections during each session. Most of them completed it during the lessons. Those who could not complete it during the lessons managed to finish it within the following one or two days. Although the trainee teachers put a great deal of effort into their learning, their reflections were to an extent rather superficial. They did not comment on the usefulness of the content or how to apply it in real situations. The length of reflections varied from 56 to 715 words.

Social design

The final result showed that the majority of groups preferred to conduct seminar discussions online. Only the first lesson seminar was conducted face-to-face. All the remaining 35 seminars were implemented online.

The use of sharing corners varied among the groups. Four groups used the group sharing corners frequently and posted a large number of messages ($n = 356$, 75.7%). For instance, one group studied one topic only, but the group members posted 85 messages. The other four groups did not use the group sharing corner quite as often ($n = 114$, 24.3%). For example another group studied two topics, but only posted 25 messages. On average, each group posted 39 messages on a topic.

The Q/A forum served the purpose of sharing information adequately. In total, 25 original messages and 29 responses were posted to the Q/A forum. Among these original messages 12 uploaded presentation files to share with other groups, 3 clarified assignments and rubrics and 2 sought technical support, with the rest being general comments.

Technological design

Basically, the Moodle platform was easy to learn and easy to use. However, sometimes the access speed was slow when all the participants used the system at the same time. Synchronous discussion messages often popped up in blocks.

The trainee teachers found the customization feature useful. Moodle allows users to update their photographs, contact numbers and email addresses. Three quarters ($n = 18$) of the trainee teachers updated their particulars. Moreover, the Moodle

system allows course creators to add important information or activities to the top of the home page. This feature was convenient, as users did not need to scroll down every time.

Perceived usefulness

As displayed in Table 1, the learning environment was perceived to be rather useful as the mean scores for those questions that were not negatively stated were high. The

Table 1. Perceived usefulness of the learning environment.

		Mean*	Min
Pedagogical	1. The function of each forum (e.g., group pages, class sharing corner) was clear.	3.8	2
	2. I learned more from the topic we studied than from other topics.	4.2	3
	3. I learned little from the presentations given by other groups.	2.8 [#]	2
	4. This learning environment was a good sample of constructivist learning.	3.8	2
	5. The various interaction (self reflection, group pages and class sharing) in this learning environment were helpful for knowledge construction.	3.4	3
	6. I liked the flexibility on learning content and assignments provided in this learning environment.	4	3
	7. The learning activities in this learning environment encouraged collaborative learning.	3.6	1
	8. I don't like the way of delivery in this course. I prefer tutor's presentation.	3	2
	9. I did not think critically when I was writing online reflections.	2.3 [#]	1
Social	10. I did not feel strong social relation existed in this learning environment.	2.8 [#]	2
	11. I liked to share my ideas, resources, questions with others in this learning environment.	3.5	2
	12. Our group members worked collaboratively on the topic(s) and/or the final project.	4.3	3
	13. The ground rules for communication and collaboration in this learning environment were clear.	3.7	2
	14. There were adequate coordination and support from the tutor.	3.7	3
	15. Seminar discussions helped me clarify issues in the presentations/topics and construct meaningful knowledge.	3.7	3
Technological	16. I could easily access this learning environment.	4.0	3
	17. This learning environment was easy to navigate and use.	3.9	3
	18. I could easily download readings from and upload resources to the learning environment.	4.0	3
	19. I did not meet difficulties during reflection writing, group sharing and online discussions.	3.2	2
	20. Help and other technical support in Moodle were sufficient.	3.0	1

Note: *: 5 = strongly agree, 4 = agree, 3 = neutral, 2 = disagree, 1 = strongly disagree; #: Negatively stated question.

results indicate that the pedagogical design of the CLE was sound. To a certain extent this learning environment presented a good example of constructivist learning and also promoted trainee teachers' collaborative knowledge construction. However, some of them did not favour the group presentation format as they were uncertain as to whether the presented content was correct.

With regard to social design, the survey results show that the learning environment promoted collaborative learning, as the trainee teachers could share information and further discuss the topics and the final project within the environment. The survey results also indicate that the discussions and collaboration helped them in knowledge construction and social relationship building.

With respect to the technological aspect, the trainee teachers agreed that the learning environment was easy to access and navigate. They could also readily download and upload resources. However, the mean score to question 19 (3.2) confirmed that the trainee teachers occasionally had difficulties when using the system. Additionally, they stated that supporting materials for Moodle were insufficient.

Further comments and suggestions were also given on the design of the learning environment. As to the pedagogical design, a number of trainee teachers mentioned that they liked the course design because it provided them with a certain flexibility to choose topics and assignments, which was not available on other courses. Two trainee teachers commented that this course was an example of student-centred learning.

Additionally, a number of comments were made on student presentations. Three trainee teachers indicated that they did not learn much from the presentations given by other groups. Another trainee teacher suggested that the presentation in each lesson should be confined to one group only. Two presentations on the same topic might result in redundancy or inconsistency. One additional trainee teacher further suggested that the group presentations should be short and precise, so that the instructor had more time to summarize.

With regard to the social design aspect the trainee teachers enjoyed the group work, as it had provided them with more opportunities to work with others. Two pointed out that the group seminar discussions should be face-to-face, as they were situated in a classroom setting where interaction online seemed to be unnecessary. In addition, one trainee teacher suggested that the questions for seminar group discussion be provided by the instructor rather than the presenters.

Regarding the technological aspect, three trainee teachers complained that the access speed to Moodle was sometimes too slow. Two additional trainee teachers indicated that using Moodle gave them a new experience, as they had never used it before.

Discussion

The purpose of this paper has been to describe the design specifications and evaluation results for a CLE. In this concluding section some issues involved in this study and implications for the design of web-based learning environments will be discussed.

Pedagogical

This research has confirmed that pedagogical design plays a crucial role in the development of ICT-enhanced learning environments. Educators commonly agree

that simple placement of hardware and software will not result in ICT integration and effective learning naturally following (Earle, 2002). The primary factor that influences effectiveness of learning is not the availability of technology but the pedagogical design (cf. Mandell, Sorge & Russell, 2002). Technology is merely a tool that makes pedagogical design feasible. In this study the pedagogical design of providing reading materials, allowing trainee teachers to add extra resources, writing online reflections and topic study in groups promoted student collaborative learning and knowledge construction.

This study has also revealed that the trainee teachers liked the learning environment to be flexible and negotiable. Constructivists claim that instructional design is a set of processes that must occur during as well as before instruction (cf. Coleman, Perry, & Schwen, 1997). The determination of student needs and learning activities is best characterized as a process of negotiation, rather than being imposed by the instructor (Jonassen, 1991). The results of this study have confirmed that the trainee teachers appreciated the design flexibility and negotiation involved in the course, as it met their various needs and expectations.

In addition, this study has indicated that the nature of a topic was an important factor that affected trainee teachers' choice of topic. It was a challenge for the instructor to moderate the process of topic selection, as some groups initially chose the same topic to study. It might be a good idea to allow the trainee teachers to propose topics to explore. Another challenge was how to assess the trainee teachers as they worked on different topics or assignments. Signing learning contracts with them might be a workable solution (cf. Codde, 1996; Knowles, 1986).

Social

Social interactivity seems to be a vital element of a CLE. In this study both face-to-face and online interaction were involved. However, trainee teachers seldom asked questions during group presentations and the presentations were, hence, likely to be one way communication. Nevertheless, many interactive social activities happened within the learning environment. It seems that using online discussion in a web-based learning environment can promote more social interaction in an inactive context. Moreover, the majority of groups chose to conduct seminar discussions online. This finding has reinforced some reported advantages of online discussions, such as providing a more comfortable atmosphere or more equal opportunities for introverted participants to voice their opinions (Warschauer, 1995) and automatically recording discussion details to make report writing easier (Wang & Woo, 2007).

This study has confirmed that social activities must be seamlessly integrated into a learning environment. We cannot assume that having been given communication tools, students will naturally interact with others. Much research has indicated that students show a reluctance to participate in online discussions, although online discussions have a number of advantages. If a social activity is not integrated or graded students may never use it at all and those who start to use it may gradually lose interest (Moallem, 2003). In this study the learning environment provided with a variety of graded social activities, such as group collaboration, seminar group discussions and whole class discussions. The results show that the participants engaged in these social activities.

Technological

This study has indicated that the technological dimension was the initial requirement for the construction of an effective computer-based learning environment. One of the differences between a computer-based learning environment and a traditional classroom setting is the degree of technology involvement. In a technology-enhanced learning environment ICT becomes an integral part of the learning process. In this study most learning activities, such as providing reading materials and online discussion and reflection, depended heavily on the use of and support by technology. Without technology the learning activities and processes would be inefficient and hard to implement. The technological aspect provided a solid base for the pedagogical and social design.

This study also identified that ease of access was critical for an online learning environment. It seems that ease of access is a crucial dimension of any network-based learning environment, because the learning activities and processes heavily depend on the support of computer networks. Research has indicated that those who have easier access tend to participate more in online learning (Harrison & Stephen, 1996). The learning process is unlikely to happen if users have difficulties in accessing the resources on the network. In this study the speed of access and response was occasionally slow. This problem frustrated the trainee teachers to a certain extent. This study has suggested that an effective online learning environment must be easy to access and available at all times.

Suggestions for further research

The results of this study suggest that several areas can be further addressed by additional research. First, the effectiveness of the CLE in knowledge construction can be further examined. In this study the usefulness of the learning environment has been investigated through observation and a survey and the results indicate that it had adequate pedagogical and social functionality and that it was also usable. However, to what extent the environment was helpful for knowledge construction has not been investigated. Superficially we observed that the trainee teachers shared and negotiated information in the group sharing corners and online discussions. Nevertheless, the extent to which it facilitated knowledge construction needs to be confirmed by further discourse analysis.

Second, the effect of the constructivist learning approach on learning outcomes needs further investigation. In this study the participants commonly mentioned that they learned more about the topics they studied than the topics presented by other groups. It seemed that the trainee teachers were more engaged in the topics they studied. It reinforced the constructivist learning theory that knowledge is actively constructed by learners themselves, rather than transmitted from others. However, the extent to which the constructivist approach can produce better learning outcomes than the traditional teacher-centred approach needs to be identified through additional research. However, some trainee teachers in this study indicated that they preferred the traditional teacher-centred approach. How to change their epistemological beliefs to achieve better results also needs to be examined.

Notes on contributor

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