Providing tools for the development of cognitive skills in the context of Learning Design-based e-learning environments

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Abstract: This paper focuses on the design of learning tools that appropriately support 'Learning Design' (Koper and Tattersall, 2005). Specifically, these tools can be used in lesson planning to encourage the development of critical thinking in learners. In particular, a Cognitive Skill-based Question Wizard (CSQ-Wizard) is proposed as a supporting tool for teachers in their attempts to design appropriate lesson plans that can encourage the development of cognitive skills in learners. The design of this CSQ-Wizard is based on modern social and constructivist views of learning. The idea, the rationale, the architecture and the interface associated with the proposed CSQ-Wizard is presented through a specific example of possible implementation within LAMS; a web-based open source environment that supports Learning Design.

Keywords: Learning design, cognitive skills, teacher education, learning activities, questions

Introduction

Traditional behaviorist learning theories (Skinner, 1968) emphasize the teacher-telling approach, which assigns learners the passive role of listening. In the context of these theories, there is sequential impressive presentation of the subject to be learned, with the emphasis on students performing 'drill and practice" activities. In other words, from this traditional perspective, the emphasis is on the presentation of the learning content. As a result, learning becomes a meaningless activity for students, mainly utilizing their memorizing skills and not their cognitive skills. Contrariwise, modern constructivist and social learning perspectives emphasize learning as an active, constructive and subjective activity where students are at the center of the learning process and it is the role of teachers to prepare fruitful environments that encourage their students to develop both critical thinking and their cognitive skills (von Glasersfeld, 1987; Vygotsky, 1978). To this end, the role of learning activity is crucial (CTGV, 1992; Noss & Hoyles, 1996; Nardi, 1996; Jonassen, 2000).

Inter-disciplinary, real-life learning activities that make sense to learners are the best motivators for their active and passionate engagement in learning; combining this kind of activity with the posing of appropriate questions could create strong learning tools. In the context of these modern learning theories, the emphasis is on the design of both learning activities and appropriate questions, as questions can play a crucial role in the development of pupils' cognitive skills (Matsaggouras, 1997). Indeed, Aristotle proposed that 'the kinds of questions we ask are as many as the kinds of things we know' (as translated by Barnes, 1994). In other words: 'knowledge resides in the questions that can be asked and the answers that can be provided' (Dym, Agogino, Eris, Frey and Leifer, 2005). Questioning is also crucial in the development of 'design thinking' implied in any scientific discipline (Dym & Little, 2003). Questions, in general, can play a crucial role in the development of learners' critical thinking and higher level thinking, enabling them to successfully face problem-solving situations and to 'transfer' knowledge from any subject area or curriculum to other areas, including everyday life (Sanders, 1966; Flanders, 1970). With the above in mind, it is clear that teacher encouragement and support for 'learning design' is essential. At this point, we shall use the term 'learning design' to indicate all the elements of learning activity design, e.g. a learning task to be posed to the students, a set of questions, the group formation, the learning materials to be used by the students, etc. (Koper and Tattersall, 2005). Within each of these elements, questions play a significant role in, for example, introducing learners to a learning activity, forming groups, building bridges between their prior knowledge and the knowledge to be learned, expressing their thinking and supporting problem solving and reflection.

Learning design is crucial in all types of education, namely; face-to-face, distance (including internet-based) and blended education. Despite the fact that there is a variety of theoretical considerations and models that provide teachers with resources for the design of learning events, in practice these mainly remain undeployed (Fosnot, 1966); in fact, teachers need *more specific* support in their learning design practices, such as specific tools and examples.

The essential role of appropriate tools to help teachers with their mindful and appropriate learning design has been acknowledged by many researchers (Roberts, Hsu, 2000; Lloyd & Wilson, 2001; Babiuk, 2005). Such tools are essential in all types of education. Essentially, in web-based education and blended education, the existence of this kind of tool is crucial for the teachers involved (Greenhow, 2004; Koper and Tattersall, 2005) as this kind of education is mainly a result of the quality of the lessons provided and not so much the emotional quality of communication that could be formed in face-to-face education.

As regards web-based education, a variety of tools is provided by well known e-learning environments. These tools can be classified into four main categories: a) communication, such as chats, forums, bulletin boards, etc. b) content presentation, c) learning organization, such as group formation, timetabling, etc. and d) learning assessment, such as automatically-corrected multiple-choice questions, portfolios, etc. In addition, a number of tools that facilitate the design of sketchy plans for learning activities and roles that learners can play are also provided (Koper and Tattersall, 2005). The latter can support a different perspective on web-based and blended education. This perspective has been named "Learning Design"; that is - when learning - people in specific groups play specific roles and are involved in learning activities using the resources and facilities integrated into the learning environment in which they participate (Koper and Tattersall, 2005). Despite this plethora of tools, tools that support the formation of constructivist lesson plans incorporating such questions that can support the development of students' cognitive skills have not yet been reported.

Taking into account all the above, we have tried to design an e-questionnaire editor; namely, a Cognitive Skill-based Question Wizard (CSQ-Wizard) to support primary and secondary level education teachers in their attempts at learning design, specifically in forming appropriate questions. This editor was designed taking into account theoretical considerations arising from modern social and constructivist theories of learning, thus enabling the aforesaid editor to aid teachers in forming such questions that should develop their students' cognitive skills.

In the following section of this paper, the rationale of the design of the proposed e-questionnaire editor is presented. Next, the architecture of this editor is described and an example of its possible implementation within the context of an e-learning environment that supports Learning Design - namely the LAMS environment - is demonstrated. Finally, the advantages of the provision of the proposed e-questionnaire editor are discussed and conclusions are drawn.

The rationale of the design of a Cognitive Skill-based Question Wizard

Critical thinking is essential for all learners (Resnick, 1988; Lipman, 1988) as it is related to their abilities to reach sound conclusions based on observation and information (Paul, 1988), to assess the authenticity, the accuracy and the worth of knowledge claims, beliefs and arguments (Beyers, 1983) and also to apply everything that they know and feel in order to evaluate their thinking (Norris, 1985). Accordingly, teachers need to diversify their teaching methods in order to encourage learners to develop their critical thinking. Conventional lesson planning focuses on what the *teacher* will do. However, when designing a learning experience for students, teachers have to focus on what *students* will do if they are to help them develop basic cognitive skills and, consequently, critical thinking. It is worth noting that, in developing lesson plans, teachers bring with them their prior knowledge and experience, which usually reflect traditional views of behaviorist learning (Papadakis, Kordaki and Hadzilacos, 2007). To this end, the introduction of teaching cognitive thinking skills in teacher education programs is essential (Martin, 1984).

Our approach encourages teachers to focus on how best to organize what learners will do while at the same time developing their basic cognitive skills. There are twenty four basic cognitive skills (CSi, i=1…24) reported in the literature. These skills have been classified into four basic groups (Matsagouras, 1997) which are briefly presented in the following section:

A) *Data collection skills,* including these specific cognitive skills:

CS1: *Observation*. This skill is related to the learner's ability to effectively use their perception.

CS2: *Recognition.* This skill allows the learner to identify things they have already learned**.**

CS3: *Recall.* This skill refers to the learner's ability to recall information from memory to use in solving a problem, answering a question or preparing the ground to understand new information.

B) *Data organization skills,* including:

CS4: *Comparison.* This skill refers to the learner's ability to detect similarities and differences among things in terms of descriptions or conclusions.

CS5: *Classification*. This skill presupposes the learner's ability to analyze and pin-point certain criteria of classification. Effective classification contributes to the understanding and consolidation of new knowledge as well as preparing the learner for efficient decision making. Classifications using different criteria illuminate multiple relationships and multiple views of reality.

CS6: *Ordering.* By developing this skill, learners are able to put certain data in order by using a specific criterion. Arithmetic calculations usually are not used.

CS7: *Hierarchy.* For data to be put in a hierarchical order, a specific characteristic is used. This kind of ordering implies the use of a unit of measurement. Arithmetic calculations make sense to the learner. When data are in a hierarchical order, the learner is provided with the ability to draw conclusions about their relationships.

C)Data analysis skills, including:

CS8: *Analysis.* This skill is related to estimation of basic parts of a whole as well as the basic principles that connect these parts. Data analysis is necessary for the discovery of patterns and relationships that govern a situation and it is a pre-requisite skill of critical thinking

CS9: *Recognition of Relationships*. This skill implies the learner's ability to discover the relationships among the parts - of the whole - detected during data analysis. Concrete visible relationships are more easily understandable than abstract relationships.

CS10: *Pattern recognition.* By discovering 'patterns' and 'frames' within the data, learners can organize and classify the information provided so that it is meaningful and understandable.

CS11: *Separation of facts from opinions*. This skill implies the learner's ability to separate their own personal opinions, which are arbitrary and sometimes biased, from facts that can be confirmed using specific data.

CS12: *Clarification.* The development of this skill aims at the clarification and enrichment of facts and concepts through the use of examples and their interrelation with previous knowledge. In this way, the understanding of a situation can be maximized while its vagueness can be minimized.

D) Data transcendence skills including:

CS13: *Explanation*. This skill means the learner's ability to integrate a specific phenomenon into a wide context as well as to interpret data in terms of finding cause-result relationships among them.

CS14: *Prediction.* This skill refers to the cause-result relationships where the existence of any patterns/structures and principles identified during the analysis stage are exploited to help learners to further predict the progress of the phenomenon at hand. Prediction and planning provide learners with opportunities to take control of the phenomenon under study.

CS15: *Forming Hypotheses*. This is a skill where the learner uncertainly and incautiously attempts to formulate cause-result relationships among data, exploiting any patterns/structures and principles identified during the analysis stage. Hypothesis formation can help learners to go beyond their data and ultimately come up with innovations.

CS16: *Conclusion.* This skill implies the learner's ability to make valid conclusions documented by the data collected and not form uncritical statements based on simplifications and biases.

CS17: *Validation.* The development of this skill means that the learner is capable of reasonable control over the experiments performed. This process aims to accept/reject the hypotheses and conclusions made in the previous stages of this experiment.

CS18: *Error detection*. This skill is related to the learner's ability to detect any inconsistencies and errors in the experimental procedure and also in the statements/hypotheses formed during the data analysis and data transcendence stages. Errors related to inductive/deductive logical reasoning could also be explored.

CS19: *Implementation-Improvement*. This skill implies the learner's ability to transfer the knowledge constructed in previous stages to similar/analogous cases, also making improvements to the solution constructed.

CS20: *Knowledge organization*. This skill means that the learner is capable of forming some diagrammatic visual hierarchical organization of the knowledge constructed during the data analysis and data transcendence stages of the experiment at hand.

CS21: *Summary.* This skill is related to the learner's ability to separate the primal and major points from minor and subordinate points and to organize the former in such a way that they contribute to a simplification of the complex situation under study.

CS22: *Empathy*. This means the learner's ability to make sense of other people's feelings and emotions regarding the situation at hand, in such a way that he/she can step back and accept the individual differences that may result.

CS23: *Assessment /Evaluation*. The acquisition of this skill means that the learner has the ability to form some criteria for the evaluation of the knowledge constructed during the experiment at hand, enabling them to define its effectiveness, appropriateness and value.

CS24: *Reflection.* Reflection has been described as the mental process of looking back over the completed experience and performance in order to assess, analyze and make connections that convert experience into learning and lead to new understandings and appreciations (Boud, Keough & Walker, 1985). Few people are able to convert personal experience into transferable learning, principles and models through the experience alone.

Teachers, on the whole, seemed unable to plan lessons using constructivism. Specifically, studies have shown that prospective teachers seemed to use questions that mainly emphasized the development of data collection cognitive skills and especially the recall of information and not the development of higher cognitive skills (Papadakis, Kordaki and Hadzilacos, 2007). To face the challenge of encouraging teachers to diversify their teaching methods in order to support learners to develop their basic cognitive skills, various supporting tools are needed. To meet this need, we designed the architecture of an e-questionnaire editor that could be integrated into the architecture of e-learning systems that support Learning Design. The proposed architecture is presented in the next section of this paper.

The proposed architecture for a Cognitive Skill-based Question Wizard

Among the various tools provided by e-learning environments are those that support the generation of questions. Despite there being a plethora of such tools, these are very generic and are not enriched in such a way as to provide specific support for the design of various types of questions or a diversity of specific questions to be included in each question-type. To this end, our proposed CSQ-Wizard aims to act as a scaffolding tool for the design of questions that support the development of critical thinking and basic cognitive skills in learners. In fact, twenty four different types of tools dedicated for the design of twenty four types of questions are proposed (QTi, i=1…24). Each type of question is assigned to each different cognitive skill mentioned in the previous section of the paper. For example, question QT5 is dedicated to the development of the cognitive skill CS5, and so on. For each type of question, a number of carefully designed questions-models are also proposed for use by the teacher. The architecture of the CSQ-Wizard is presented in Figure 1, while the proposed question-models (QMij, i=1…24, j=1…3) for the formation of each type of specific question are presented in Table 1.

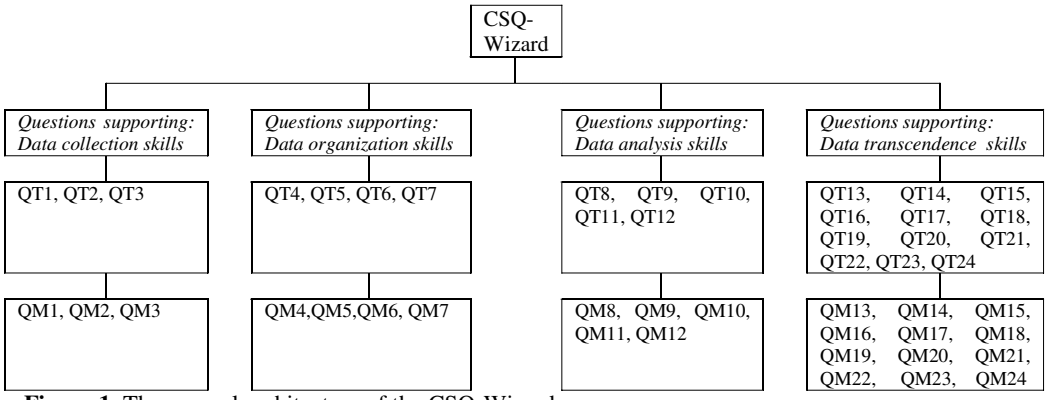

Figure 1. The general architecture of the CSQ-Wizard

List of Basic Cognitive Skills		Examples of question-models (QMij, i=124, j=1..3)
Data collection	**CS1. Observation**	*QM11: What do you observe ...* *QM12: What do you see…?*
	CS2. Recognition	*QM2: Please identify…*
	CS3. Recall	*QM31: Give the definition of…* *QM32: What is the meaning of…?* *QM34: What has been said by… about…?*
Data organization	**CS4. Comparison**	*Compare these… using the following criteria…* *Find the pros and cons of…* *Find both the similarities and the differences between.. and…*
	CS5. Classification	*Group these elements using the following criteria…* *Find the pros and cons of these…solutions* *Find 5 advantages and 3 disadvantages of …*
	CS6. Ordering	*Find a criterion to order these…* *Order these…* *Find the 5 biggest/smallest …*
	CS7. Hierarchy	*Arrange these…by the following criterion…* *Sort these… by the following criterion…* *Put these…in an ascending/descending sequence…*
Data analysis	**CS8. Analysis of basic parts**	*Identify the parts/units/characteristics of…* *Define the data given and the objectives of….* *Refer to the appropriate phases of the solution plan for…*
	CS9. Flush out relationships	*Distinguish possible relationships among the data…* *Is there any reason that affects this phenomenon…?* *Is there any structure within…?*
	CS10. Pattern recognition	*Is there any pattern that is repeated in…?* *Find out what is common in…* *Find out what is similar in…*
	CS11. Distinction between facts & opinions/judgements	*Clarify whether this …describes a fact or if it is a personal opinion* *Provide more than one view about the following…* *Provide logical arguments to support the following statement*
	CS12. Clarification	*What do we mean by…?* *Provide an example to clarify…* *When does this…have a meaning…?*
Data transcendence	**CS13. Explanation**	*Please explain how/why/what/the meaning of/…* *Please explain in your own words…* *Could you provide any interpretation of the behavior of…?*
	CS14. Prediction	*Could you make any predictions about…?* *If we do…then what will happen?* *In the case of…find out…*
	CS15. Hypothesis	*If … then…*
	CS16. Conclusion	*Based on this/these…what do you conclude?* *Are there any exceptions to…?* *Are there any weak points in…?*
	CS17. Verification	*Please verify that…* *Please confirm that…*
	CS18. Error and conflict detection	*Point out the mistakes of/in…* *Are there any contradictions in…?* *What is missing in…?*
	CS19. Application and Improvement	*How can you improve this…in order to…?* *How can you apply this…in order to…?*
	CS20. Knowledge Organization	*Make a hierarchical tree to describe…* *Can you form a sequential structure of…?* *Characterize it according to the following criteria…*
	CS21. Summary	*Form an abstract of …(number) words to describe…* *Which are the main points of …* *Which are the top 5 essential points of …*
	CS22. Empathy	*Could you accept the role of…?* *What are the possible arguments of others for…?* *What would be your answer if you were in the position of…?*
	CS23. Assessment/Evaluation	*Assess/evaluate this…* *What kind of criteria can you use to evaluate the…?*
	CS24. Reflection	*What have you learnt about…?* *Are there any points that you…?*

Table 1. Examples of question-models that could be used to develop basic cognitive skills in learners

An example of implementation of the proposed CSQ-Wizard within LAMS

LAMS (Learning Activity Management System; http://www.lamsfoundation.org/) is an open source tool for designing, managing and delivering online collaborative learning activities. When using LAMS, teachers gain access to a highly intuitive visual authoring environment for the creation of sequential learning activities. These activities may be individual tasks, small group work or whole class activities. LAMS is based on the belief that learning does not arise simply from interacting with content but from interacting with teachers and peers. The creation of content-based, self–paced learning objectives for single learners is now well understood in the field of e-learning. However, the creation of sequential learning activities which involve groups of learners interacting within a structured set of collaborative environments - referred to as 'learning design' - is less common; LAMS allows teachers to both create and deliver such sequences. In essence, LAMS provides a practical way to describe multi-learner activity sequences and the tools required to support these. In fact, LAMS provides tools that support various activities such as communication, presentation of information, writing and sharing resources as well as posing and answering questions. Despite this fact, the tools that supports the generation of questions are very generic (see Figure 2). Consequently, we suggest the integration of the proposed CSQ-Wizard within the Questions and Answers tool provided by LAMS (see Figure 3).

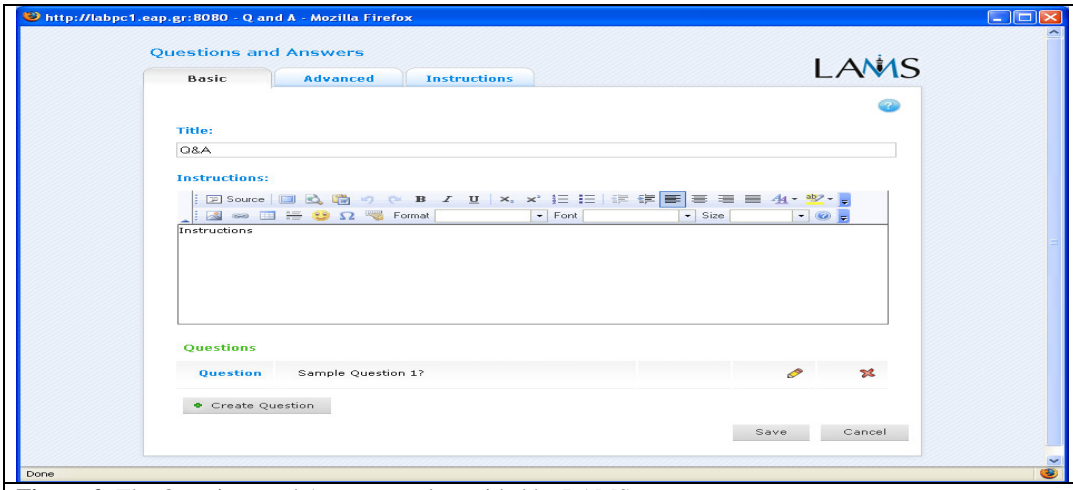

Figure 2. The Questions and Answers tool provided by LAMS

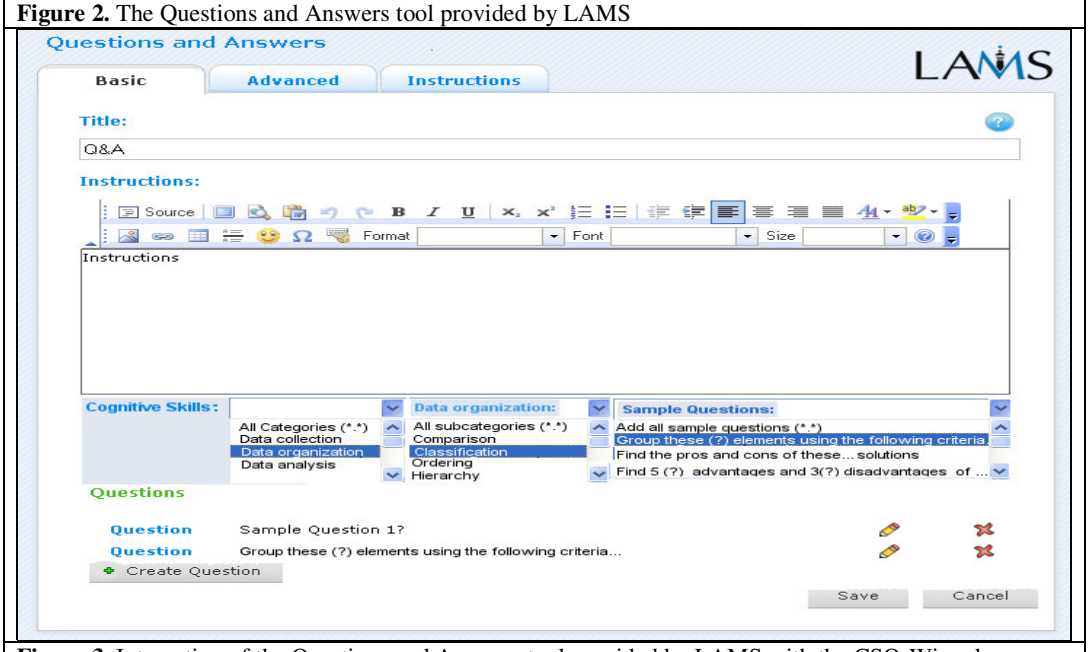

Figure 3. Integration of the Questions and Answers tool provided by LAMS with the CSQ-Wizard

As it is shown in Figure 3, when the CSQ-Wizard is integrated into the Questions and Answers tool, teachers are provided with the opportunity to construct the four categories of questions described in the previous section. They can select a specific question category, e.g. the questions that support data organization cognitive skills. Subsequently, they are presented with all types of questions included in this category, namely; Comparison, Classification, Ordering, Hierarchy (see the second pulldown menu in Figure 3). At this point, the teacher can select a specific type of question, e.g. those that support the development of classification cognitive skills, and then be provided with some question-models that help form appropriate questions (see the third pull down menu in Figure 3).

Conclusion and plans for future work

This paper has presented the idea and the architecture of an e-questionnaire editor - the Cognitive Skill-based Question Wizard, or CSQ-Wizard - dedicated to supporting teachers in their design of lesson plans to form such questions that encourage the development of basic cognitive skills in learners. The design of this editor has taken into account social and constructivist theories of learning. In fact, the CSQ-Wizard consisted of twenty four – the number of basic cognitive skills - tools to construct an equal number of types of questions designed to support the following cognitive skills: A) *Data collection skills,* including the specific cognitive skills of: Observation, Recognition and Recall, B) *Data organization skills,* including: Comparison, Classification, Ordering and Hierarchy, C) *Data analysis skills, including*: Analysis, Recognition of Relationships, Pattern recognition, Separation between facts and opinions and Clarification, and D) *Data transcendence skills,* including: Explanation, Prediction, Forming Hypotheses, Conclusion, Validation, Error detection, Implementation-Improvement, Knowledge organization, Summary, Empathy, Assessment /Evaluation and Reflection. Each type of these questions is dedicated to support the development of a basic cognitive skill. For each type of question, question-models are also designed to present the teachers with good ideas and to help them to form appropriate questions. Integration of the proposed CSQ-Wizard within the Questions and Answers tool provided by LAMS is also presented. However, it is worth noting that the architecture of the proposed CSQ-Wizard can be integrated into e-learning environments that support learning design. By using the CSQ-Wizard, teachers have the opportunity to design questions, not by chance but in a focused way, aiming towards the development of cognitive skills in learners. In the construction of such questions, teachers are also provided with question-models which can act as scaffolding elements to this process. The potential features of the proposed CSQ-Wizard being theoretical, field studies are deemed appropriate to test its impact on the attempts of real teachers at learning design.

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