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Toward an intentional model aware of learner cognitive traits for pedagogical process guidance

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Abstract

Previous research on adaptive learning successfully demonstrated that use of Intentional Model for Educational Processes Guidance has gained popularity in Intelligent Tutoring System. Within this context, the novelty of this version of Intentional Model of Pedagogical Process Guidance (IMPPG) is the effectiveness use of Cognitive Trait Model to be aware of different traits of learner. The proposed model leads to generate an individualized learning for each learner by selecting the most appropriate pedagogical process according to the actual preferences of the tutor and the cognitive traits of learner. In fact, this model couples the pedagogical intention with the pedagogical strategies and provides a multitude of paths between learner intentions. Based on the cognitive traits of the individual learners and the corresponding pedagogical method or the individual teaching style, the ITS adopts the proposed model to adaptively support the tutor to achieve his/he intention through the selected strategy. This model has been experimented and assessed with tutors and students learning spreadsheet management in a first-year studying in applied license's degree in Business English and applied license's degree in Education. The first results show that the intentions and the strategies selected by our model were relevant according to students' needs and tutors' preferences. In the initial tests, the process model has met what was expected, however, more studies with experiments must be carried out. The primary results are reported and discussed in the paper; several lessons learned from the experience and potential improvements are also included.

Keywords: Intelligent tutoring system, Guidance, Pedagogical process, Intentional model, Learner, Cognitive trait model

Introduction

Enhancement of learning and tutoring with technology has been accelerated thanks to the advancement of artificial intelligence (IA) and the development of IA Techniques in the areas of learning, tutoring and training. In fact, the use of artificial intelligence (AI) in education is inevitable by the increasing utilization ITS which are designed to replicate the effectiveness of one-to-one human tutoring by using the IA techniques. By using ITS, some tutors find it easy to guide learners in a particular situation, others find the same situation difficult and have severe pedagogical problems. The reason can be seen in the preferences of tutors, and the learners' individual differences, such as their different cognitive states, preferred styles, and abilities. In fact, current ITS do not address pedagogical preferences of tutors and learners' individuality regarding their various levels of input knowledge and their different cognitive styles, which, in our case, are based on cognitive traits. Although various ITS been used to facilitate teaching and learning, majority of these systems do not have features for analyzing data and identifying learner characteristics such as learning styles (LS) and cognitive traits (CT).

Therefore, learner behavior modeling has received much attention over the last two decades (Chrysafiadi and Virvou, 2013; Abyaa et al., 2019). In fact, a learner model is a key component of any ITS as it maintains information of learner behavior in order to provide them appropriate tutoring according to current learning needs. For that, the CTM (Kinshuk & Lin, 2003; Lin & Kinshuk, 2005) is a student model that profiles learners according to their major cognitive traits for learning (Graf et al., 2009).

Within the field of ITS design, the problem of trying to replicate the benefits of computer-assisted learning tools involves adding features that adapt to individual learning needs of students and personal pedagogical preferences of tutors. In that spirit, the intelligence of ITS represents applying IA techniques methods in guiding the educational processes (Bayounes et al., 2022a, 2022b). Different studies are conducted on this issue (Francisco & Oliveira Silva, 2022; Huang et al., 2022; Saâdi et al., 2020; Tato et al., 2022). But at that time, several studies of ITS design (An et al., 2022; Fang et al., 2022; Mousavinasab et al., 2021) identify the gap between the cognitive traits of learner and their practical implementations in pedagogical process guidance. Therefore, given this gap, a further systematic literature review is necessary to gain insights that can close the gap. By conducting this review, the proposed study presents an important academic revolution in ITS design by considering the different individual cognitive traits of learners to guide the generation of appropriate pedagogical process. The whole aim of this revolution is the comfort of tutors (tutoring in the personalized way). To achieve the goal above, we proposed three primary research questions in this study:

- RQ1. What is the most appropriate cognitive trait model for pedagogical process guidance?
- RQ2. How the cognitive trait model was considered by the intentional model for pedagogical process guidance?
- RQ3. What are the challenges in applying the intentional model aware of learner cognitive traits for pedagogical process guidance?

In order to respond these questions, this research proposes a new version of intentional model for pedagogical process guidance. This version adopts CTM to select the most appropriate pedagogical process for learner. In fact, this model aims to bring effective solution to the pedagogical process definition, enactment and reuse in an ITS. Therefore, in this paper, we propose an intentional model for pedagogical process using Map formalism which allows us to design several processes under a single representation (Rolland, 2007). Furthermore, our model is the best solution to adapt and orient the pedagogical process to the educational context by applying different guidelines.

The remainder of this paper is organized as follows. "Related work" section presents a short description of related work on cognitive trait and intentional modeling for pedagogical process guidance. "Material" section provides an overview of the pedagogical progression by specifying two examples of model guideline. "Method" section discusses the results of experimentation. Finally, we conclude and outline several topics of potential future work.

Related work

Over the past few years, there is a growing set of contributions in adaptive learning based on cognitive style. In fact, the cognitive styles refer to "people's characteristic and typically preferred modes of processing information (Sternberg, 1997). This style is a person's habitual, prevalent, or preferred way of thinking (Riding, 1997). In particular, the term cognitive style has been used to refer to a person's habitual way of learning or teaching (Sternberg, 1997).

Within this context, the concept of cognitive style describes how individuals consistently differ in how they use their cognitive capacities (Liedtke & Fromhage, 2019). It is important to note that cognitive style differs from intellectual ability (Ponce-Garcia & Kennison, 2013). Cognitive style refers to one's manner of performing. In contrast, intellectual ability refers to one's level of performance (Ponce-Garcia & Kennison, 2013). This ability is measured by different cognitive traits.

These traits measure learners' psychological attitude towards learning (Drachsler & Kirschner, 2012). For that, the learner model collects and processes information on student behavior such as cognitive traits (Lwande et al., 2021). On other hand, the knowledge of cognitive traits enables instructional designers to specify relevant tutoring for a target group. In fact, the tutor must consider the cognitive traits of learners during the pedagogical process to reach the pedagogical goal and the learning objectives.

More specifically, in this this section, we specify the cognitive traits model and relate them to the adaptive learning supported by ITS and we present the proposed model of pedagogical process guidance. Furthermore, we provide an overview of how cognitive traits can be can be used in the proposed model.

Cognitive traits model

There are numerous cognition models in the literature, out of which the CTM is the most effective model to overcome the challenge of adaptive learning (Lin, 2007). This model is based upon the idea that there are four key cognitive traits in learning which can guide the pedagogical process construction. This model is particularly important for e-learning, since considering the major cognitive traits of learners by the tutors in an online course is more difficult than in face-to-face courses. Therefore, this research adopts the CTM to guide the pedagogical process construction in ITS.

The proposition of CTM changes the traditional idea of the student model that is thought of as just a database sitting on the server which is full of numbers for only a particular task (Graf & Kinshuk, 2008). The CTM offers the role of 'learning companion', which can be consulted by and interacted with different learning environments about a particular learner (Graf & Kinshuk, 2008). The CTM can still be valid after a long period of time due to the more or less persistent nature of cognitive traits of human beings

(Deary et al., 2004). Furthermore, cognitive traits can be seen as domain and context independent (Kinshuk & Lin, 2005). Four cognitive traits, working memory capacity, inductive reasoning ability, information processing speed, and associative learning skills are included in CTM so far (Graf et al., 2009).

Among the various models, the CTM has been considered as a systematic and easy-to-apply model for defining the major cognitive traits of the learners. Recent developments in online learning renewed the interest in using the cognitive trait model. According to Karampiperis et al. (2006) the CTM is used to support an adaptive selection of learning object in web-based learning system. Khenissi et al. (2017) adopt the model to develop educational game. Moreover, it was used to des the designing of educational games for learners with special needs (Khenissi et al, 2015). More recently, Choi (2022) utilized the model to measure the mastery level and progression of learning. Lwande et al. (2021) combined both felder-silverman learning style model and cognitive trait model to estimate learning styles from learning management system (LMS). Only a few such as Trifirò and Laing. (2021) investigated the use of model to adapt the teaching methods. Thus, the studies highlight the need for further research to demonstrate how the cognitive traits of learners can be considered by the tutors to adopt the appropriate pedagogical process.

For that, the CTM provides a basis for designing pedagogical activities that support the learning achievement. In fact, it is used as the theoretical basis of the intentional models for educational processes guidance. For the current research, it is adopted to specify the adaptive construction arguments of appropriate pedagogical process.

Working memory capacity (WMC)

In earlier times, working memory was also referred as short-term memory (Graf et al., 2009). Richards-Ward (1996) named it as the Short-Term Store (STS) to emphasise its role of temporal storage. Working memory allows us to keep active a limited amount of information (roughly $7+2$ items) for a brief period of time (Miller, 1956). In fact, working memory capacity refers to the transient memory storage to achieve a limited amount of information for a short time (Lin, 2007).

Matching courses to the working memory capacity of individual learners aims at considering their abilities and therefore avoiding cognitive overload (Graf & Kinshuk, 2008). For learners with low working memory capacity, this can be achieved by informing the objectives and presenting the most appropriate concrete content. In contrast, for learners with high working memory capacity, content with a somewhat wider overview can be presented and reinforced by the suitable abstract content.

Inductive reasoning ability (IRA)

This trait refers to the ability to generalize an abstract entity from an instance (Heit, 2000; Kinshuk et al., 2006). The abstract could be a rule, a theory, a principle, or a model to explain certain phenomenon (Lin, 2007). In fact, the inductive reasoning ability is a significant factor for problem solving, concept learning, and the mathematics learning (Haverty et al., 2000). For learners with low inductive reasoning ability, many opportunities for gaining attention of learner should be provided. Furthermore, ITS can support these learners by providing a high amount of well-structured and concrete learning content with many presentation paths. For learners with high inductive reasoning skills, the amount of content should decrease to reduce the complexity and hence enable the learners to grasp the concepts quicker.

Associative learning skills (ALS)

The associative learning skills link new knowledge to existing knowledge. Many of the studies about associative learning are based on the assumption that the association can be formed between simple events or stimuli (Bonardi, 1998). In order to assist the association processes during the learning situation, the tutor needs to stimulate the recall (revisit) of learned content, to clearly show the relationships of prerequisites and the objectives, and to facilitate new or creative association/insight formation by providing suitable pedagogical content of the related learning domain area.

Moreover, well-structured content makes linkage between learning concepts easier for learners with low associative learning skills. In contrast, for learners with high associative learning skills, less structure of content allows them to explore the learning domain more freely.

Information processing speed (IPS)

Information processing speed determines how fast the learners acquire the information correctly (Graf & Kinshuk, 2008). For learners with low information processing speed, only the required learning performance should be elicited and assessed. In contrast, for learners with high information processing speed, the learning performance can be extended by providing individual and group projects.

Pedagogical process model

Process context

While several definitions have been reported in the literature, most of them focus on the tactical process modeling (Bayounes et al., 2012, 2020). Various works view pedagogical processes as a set of phases without respecting the different goals to achieve and the various strategies to apply. Moreover, the different learning needs and the pedagogical preferences are not well considered by various studies in the literature (Paris et al., 2021).

To tackle this problem, this study particularly focuses on strategic and intentional specification of pedagogical preferences and the cognitive traits of the learners to guide the pedagogical process construction. For that, it proposes a strategic perspective of process modeling by choosing the Map formalism to specify the different types of intention to achieve and the various strategies to apply (Rolland, 2007). This formalism will guide the pedagogical progression by supporting the selection of the appropriate educational intention and the suitable strategy according to the tutor's preferences and the cognitive traits of the learner.

Before the model definition, we start by specifying the process context. The pedagogical process model is viewed as a didactical goal achieved by defining the pedagogical product model (Bayounes et al., 2014). The latter specifies the didactical content presented by the tutor (Bayounes et al., 2014). The didactical goal refers to a major intention to reach by a process model. The different goals are the knowledge transmission, the knowledge acquisition, and the knowledge building (Bayounes et al., 2014). The different types of knowledge are declarative, procedural, and metacognitive (Bruning et al., 1995).

Model definition

The present model is based on the homogeneity of the expression of learners' needs and tutors' requirements to reduce the conceptual mismatch between learning paradigms. It enables rethinking of pedagogical process by adopting the intentional and the strategic dimensions. For that, the process description is oriented to the objective that the process can achieve.

The proposed model introduces variability in the way of achieving the goal of the pedagogical process. The variants correspond to different ways to reach the goal. In fact, the pedagogical process may be composed of several intentional processes with different purposes and the associated variations. It follows that these variations are based on the relevant context variables which are presented by the intentional pedagogical process. We believe that the encapsulation of alternative actions in the definition of an intentional pedagogical process supports the dynamic adaptation of intentional process to the specific conditions of pedagogical situation. The variability introduced into the process model allows for defining the common characteristics of goal achievement by identifying the variations to meet the cognitive traits of learners' and the pedagogical preferences of tutors.

The formalism of pedagogical process modeling is based on MAP meta-model (Bayounes et al., 2014). It is represented by an oriented and labelled graph, where the intentions are nodes and the strategies are arcs (Rolland, 2007). It is composed of intentional part and guideline part (Bayounes et al., 2013). The intentional part differentiates between the objective to reach and the strategy to apply (Bayounes et al., 2013). The guideline part helps user to navigate with the Map (Bayounes et al., 2013). Moreover, fulfilling a specific intention with a particular pedagogical strategy can be related to a specific guideline defining the activities to perform (Saâdi et al., 2020). The key element of a map is a section defined as a triplet and represents a way to achieve the target Intention I2 from the source Intention I1 following the strategy S12; this section is expressed as follows S: < I1, I2, S12 > (Saâdi et al., 2020).

Based on the condition of learning theory (Gagné, 1985), the pedagogical process model is based on eight intention types, namely gaining attention, presenting the content, informing learners of objective, stimulating the recall of prerequisite, reinforcing the content, assessing the performance, eliciting the performance and extending the performance (see Fig. 1).

This model adopts the new classification of pedagogical strategies to achieve the major intentions (Bayounes et al., 2014). This classification is based on Reigeluth's instructional strategies (Reigeluth, 1999), which defines cognitive, metacognitive, social, and affective strategies.

The cognitive strategies are beneficial to the tutor because they help to present and explain content (Bayounes et al., 2014). The metacognitive strategies help the tutor to regulate the pedagogical process (Bayounes et al., 2014). The social and the affective strategies are very important in teaching because they are used in communication and control of emotions of the learners by the tutor (Bayounes et al., 2014).

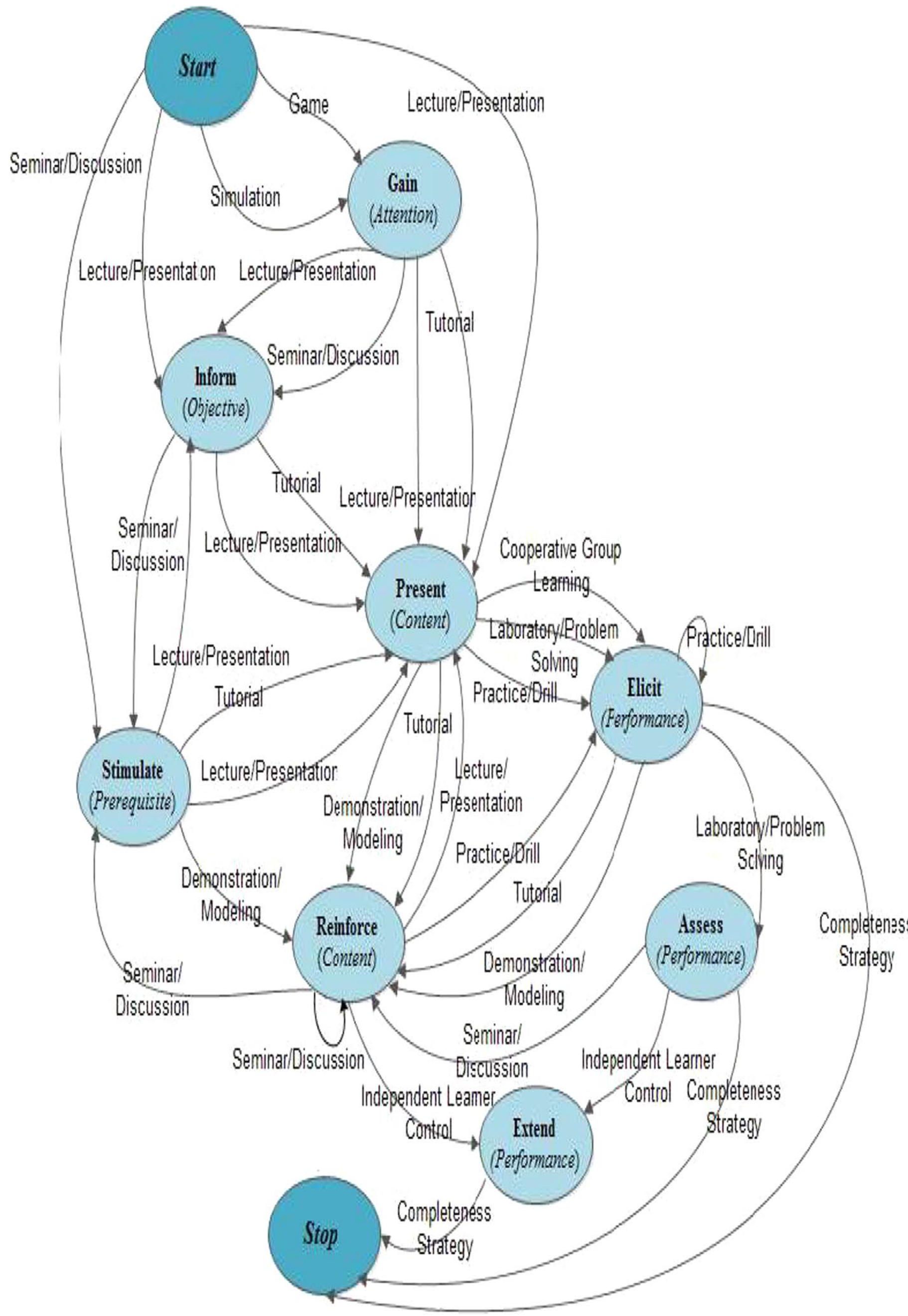

Fig. 1 Pedagogical process model (Saâdi et al., 2020)

In order to guide the pedagogical process progression, the proposed model includes three types of guidelines (Saâdi et al., 2020):

- *Intention achievement guideline (IAG)*: This guideline is associated with every section and defines how to realize the target intention from the source intention following the selected strategy. Thus, it guides the achievement of current intention by applying an appropriate strategy;

- *Intention selection guideline (ISG)*: This guideline is associated with the intention. It supports the progression by selecting the next intention to be accomplished according to the current values of context variables;
- *Strategy selection guideline (SSG)*: This guideline is associated with a couple of intentions. The purpose of this guideline is to guide the selection of a suitable strategy according to the current values of context variables.

So, we can say that intention selection guideline (ISG) and strategy selection guideline (SSG) help to progress in the map, i.e., to select the next intention and to select the next section, respectively.

Material

The educational context of pedagogical processes construction includes different variables ranging from different pedagogical situations. The major variables are the learning style, teaching style, learning mode, pedagogical orientation, pedagogical method, personality type, cognitive traits and electronic media. In fact, the exploration of pedagogical process model which is guided by different variables of educational context.

In particular, this section introduces the arguments of exploration, which are adopted to guide the pedagogical progression based on the defined process model. Moreover, examples of guidance were illustrated to conduct the experimentation of the proposed model.

Arguments of pedagogical process guidance

Our process model is based on the adaptation of Map guidelines to pedagogical context by specializing Intention Achievement Guidelines (IAG) into cognitive, metacognitive, social, and affective guideline based on pedagogical strategies (Bayounes et al., 2014). To explore the process model, we have also classified, and refined arguments considered in the choice criteria of an alternative based on persuasive or logical objective of argument into logical argument, quasi logical argument, and rhetorical argument (Bayounes et al., 2013, 2014; Saâdi et al., 2020). A logical argument (LA) is guided by a clear thinking (Bayounes et al., 2014; Saâdi et al., 2020). A quasi-logical argument (QL) is supported by the experience (Bayounes et al., 2014; Saâdi et al., 2020). A rhetorical argument (RA) depends on the individual preferences (Bayounes et al., 2014; Saâdi et al., 2020).

Various pedagogical methods are considered to define the logical argument. In fact, the five major methods are direct instruction, indirect instruction, interactive instruction, experiential learning, and independent study (Petrina, 2007). The quasi-logical argument is specified by the cognitive traits of the learner. It is based on the cognitive traits model (Lin & Kinshuk, 2005) by defining four major traits, namely working memory capacity, inductive reasoning ability, associative learning skill, and information processing speed. The rhetorical argument is identified by the five dimensions of felder-silverman correspondent teaching style, namely content, presentation, organization, learner participation, and perspective (Felder & Silverman, 1988). The first dimension distinguishes between a concrete and an abstract pedagogical content. The second dimension identifies the presentation modes of content. The third dimension of processing covers the student participation. In the fourth dimension of organization, tutors are characterized according to their way of organization. Finally, the fifth dimension of perspective distinguishes between a global and a sequential mode. By adopting these arguments, the selection criterion (SC) is defined as SC = QL AND (LA OR RA). The guidelines and argument refinements offer us more flexibility for pedagogical process guidance in ITS.

Examples of pedagogical process guidance

In this section, the different examples of model guidelines are described to illustrate the pedagogical progression.

Example of guidance by selecting appropriate intention

After the achievement of the current intention, the ISG guideline guides the progression by selecting the next intention to be accomplished according to the cognitive trait of the learners and the pedagogical method or the teaching style. For example, the guideline ISG1 < (Session, With State(Session) = Started), Progress from Start > supports the process progression by recommending the selection of the first intention between presenting the pedagogical content, informing the objectives, stimulating the prerequisites and gaining the learner's attention (see Fig. 2). The selection of presenting the pedagogical content depends on the high working memory capacity of learner and the direct pedagogical method which is based on the visual presentation of an abstract content. The gaining intention is achieved by the high inductive reasoning ability of learner and the experiential or the independent study method which are based in the active participation of learners. However, the high speed of information processing and the direct or the interactive pedagogical method can be adopted to achieve the informing intention. Finally, the high associative information skill of learner and the indirect or the interactive pedagogical method can be used to reach the stimulating intention.

Example of guidance by selecting suitable strategy

The purpose of this guideline is to guide the selection of the suitable strategy to inform the objective according to the cognitive traits of the learners and the pedagogical method or the teaching style. In order to satisfy this purpose, we present the guideline having the following Signature SSG2: < Attention, With State (Attention) = Gained), Progress towards the Inform (Objective) > (see Fig. 3). This guideline specifies how to inform the objective by choosing the lecture/presentation strategy or the seminar/discussion strategy. The selection of the presentation strategy depends on the high capacity of working memory and the indirect or the direct methods which are based on the visual presentation of pedagogical content. The seminar/discussion strategy is based on the high associative learning skill of the learner and the interactive method which is based on the verbal presentation of pedagogical content.

Method

The experimentation was conducted at a public Tunisian university. It took place during January-May 2020. The aim of this experiment was to investigate the performance of the intentional model for pedagogical process guidance based on the cognitive traits of the

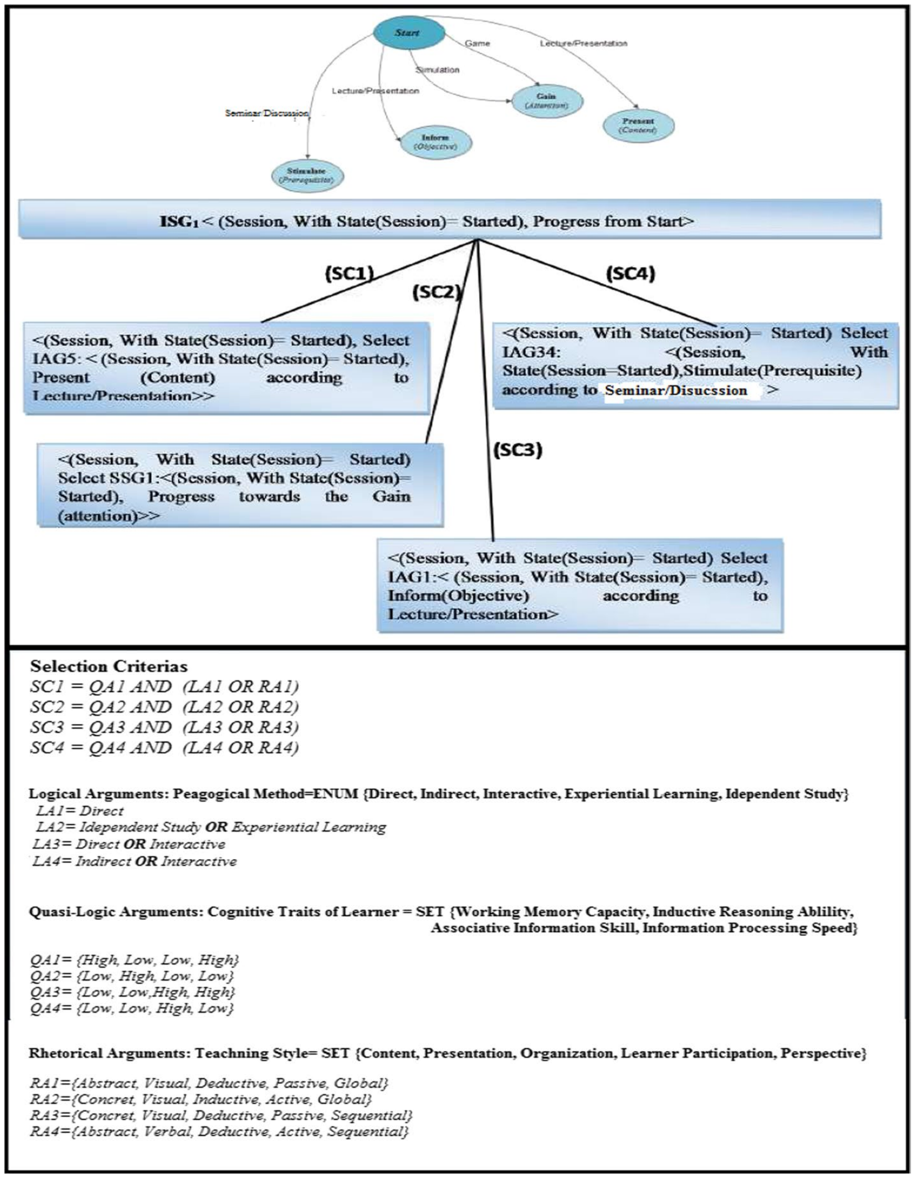

Fig. 2 Example of intention selection guideline

learners. Before the result analysis, this section describes the participants and the instruments used to conduct the experimentation procedure.

Participants

Five tutors and fifty students (18–22 years old) participated in the experiment. This experimentation involved 25 participants studying in applied license's degree in Business English and 25 participants studying in applied license's degree in Education Sciences. In order to evaluate the usability and effectiveness of the proposed model, the selection of the participants was based on their ability of spreadsheet management through their previous experiences of using Microsoft Excel to do their work.

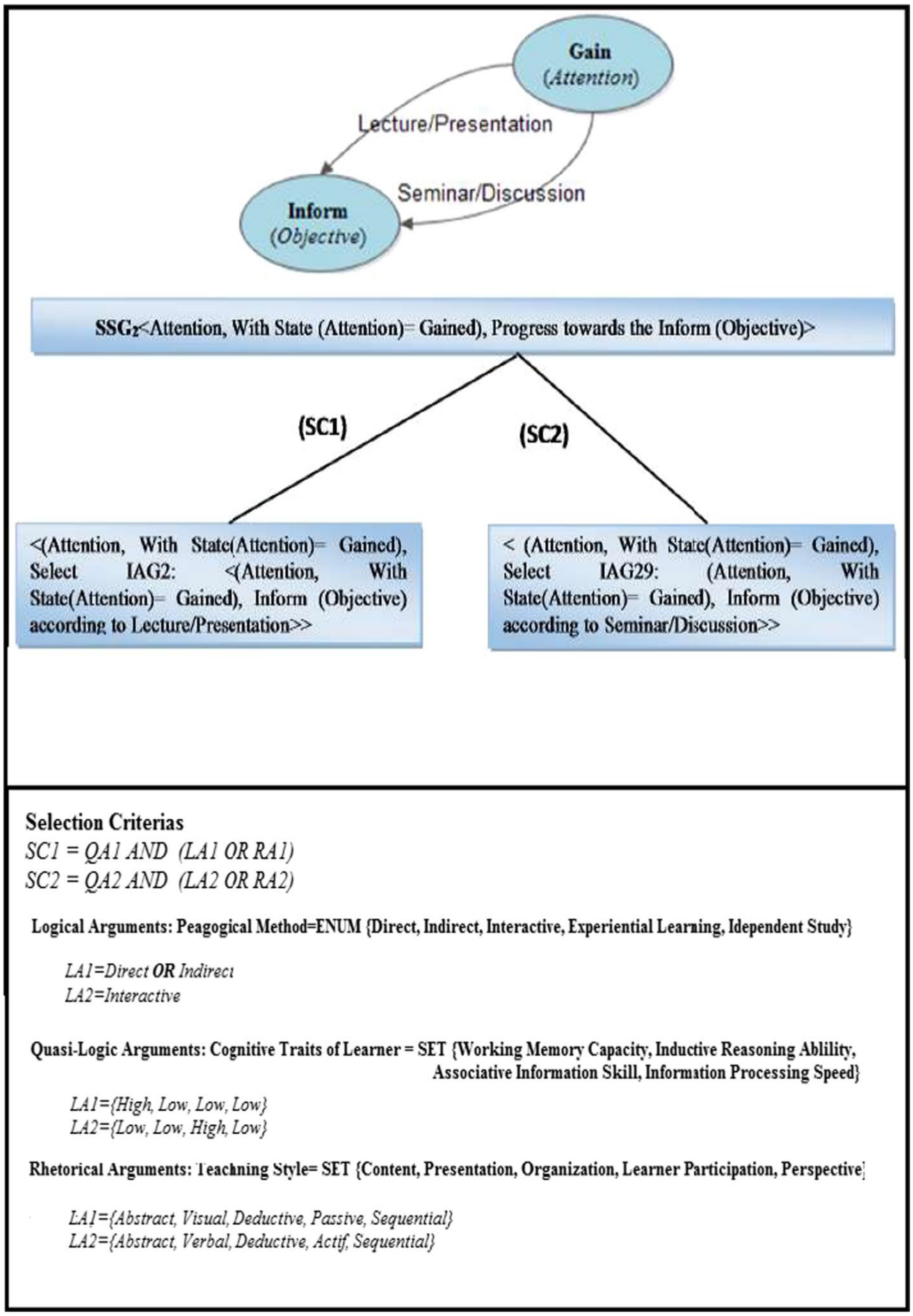

Fig. 3 Example of strategy selection guideline

However, only 40 students (15 male and 25 female) actually finished the online learning process. Specifically, the other 10 students dropped out of the course at different phases (i.e., some students dropped out of the course in the first week, while others after a couple of weeks). This study analyzed the log data of the students who finished all the learning processes for five weeks (40 students).

All the students reported that they had never taken a fully online learning experience before. The average age of the students was 19 years old, with 65% being female.

The students were randomly divided into two groups, namely experimental and control groups. All students were already familiar with using electronic devices, such as mobile phones and computers, for information searching and communication, but had not previously used any ITS for learning. The followed experimental procedure is presented in the next subsequent section.

Experimental procedure

This experimentation is based on a course about Microsoft Office Specialist certification (MOS) Excel 2019 that was taught to undergraduate students in the second semester at a university in Tunisia. The online course had six lessons, covering the main concepts of certification. The lesson was composed of commonly used teaching and learning activities and the lecture slides to explore the main concepts. When registering in online learning environment of the university, namely Moodle, the tutors filled out the Index of Teaching Styles questionnaire (Felder & Silverman, 1988) so that their teaching styles could be identified and stored in Moodle. This questionnaire is an often-used instrument and consists of 40 questions, 10 for each dimension. Moreover, the students' cognitive traits were measured by adopting the web-based psychometric tests, namely Web-IRA, Web DAL and Web OPSAN (Lin, 2007). These tests can be used to initiate a student cognitive profile (Lin, 2007). Finally, the required pedagogical methods were defined by the lesson syllabus.

According the results of previous questionnaires and tests, the pedagogical processes are specified. After that, the students in each group (experimental and control) took thirty minutes to answer a pre-test and a pre-motivation questionnaire to assess the motivation level and the prior-knowledge related to spreadsheet management. The students in the experimental group then used the well-defined pedagogical process (with DPP), while the students in the control group used the non-defined pedagogical process (without DPP). For each student of experimental group, the tutor starts the lesson by explaining the predefined process. Finally, after the pedagogical process was ended, the students in both groups completed a post-test and a post-motivation questionnaire.

Instruments

Both qualitative and quantitative data from both the students and the tutors are collected using the following four instruments. The main idea is that the results from qualitative analysis should further support and explain the quantitative results.

Pre and post-test

It was designed by experienced teachers who had the MOS Expert certification. This test contains three different items and aims to measure each student's learning performance regarding certification items. The students took between 35 and 45 min to finish this test. It should be noted that the pre and post-tests are the same and 10 is the highest grade that a student can obtain.

Pre and post-motivation questionnaire

The motivation questionnaire was adapted from Wigfield and Guthrie (1997). It aims to measure the motivation level of students during the pedagogical process. It consists of nine items on a four-point scale (1 strongly disagree; 2 disagree; 3 agree; and, 4 strongly agree). The Cronbach's alpha of the questionnaire was calculated and it was equal to 0.83. This implied that it was reliable since Cronbach's alpha value was greater than 0.7 (Yu, 2001). It should be noted that the pre- and post-motivation questionnaires are the same.

Usefulness grid

After the achievement of different teaching and learning activities of the lesson, the tutors were asked to assess the usefulness of each section of proposed pedagogical process on a five-point Likert scale (0: never; 1: rarely, 2: sometimes, 3: often and 4: always). The mean of usefulness for different sections determined the overall usefulness of predefined process.

Based on the various cognitive traits of the students, a total of 32 pedagogical processes were selected for two lessons of certification course (LA: Formatting Charts, LB: Conditional Formatting). Table 1 specifies the key selection criteria of processes.

Student achievement interviews

A semi structured interview was conducted with the students to collect his feedback about respecting the well-defined pedagogical processes. The interview took 40 min and it was recorded in order to be analyzed and draw conclusions. The coding process was done by two coders, and in case of disagreement, the two researchers resolved it through discussion.

The coders mainly focused on four aspects of learning performance achievement which can affect the cognitive traits. Specifically, four codes were used for the qualitative analysis of interviews, namely: (1) Identify learning obstacle: Use this code when the

Table 1 Selection criteria of pedagogical processes

Pedagogical processes		**Cognitive traits of learner**			
LA	**LB**	**WMC**	**IRA**	**ALS**	**IPS**
P1	P17	High	Low	Low	Low
P2	P18	Low	High	Low	Low
P3	P19	Low	Low	High	Low
P4	P20	Low	Low	Low	High
P5	P21	High	Low	High	Low
P6	P22	High	High	Low	Low
P7	P23	High	Low	Low	High
P8	P24	High	High	Low	High
P9	P25	High	High	High	Low
P10	P26	High	Low	High	High
P11	P27	Low	Low	Low	Low
P12	4P28	Low	High	Low	High
P13	P29	Low	High	High	Low
P14	P30	Low	Low	High	High
P15	P31	High	High	High	High
P16	P32	Low	High	High	High

student is talking about how adopting the predefined pedagogical process helped him in identifying the learning obstacle (difficulties, wrong answers, etc.); (2) Give timely intervention: Use this code when the student is talking about how considering the predefined pedagogical process helped him in receiving immediate or effective learning interventions; (3) Ensure peer learning: Use this code when the student is talking about communication and interaction between students while respecting the predefined pedagogical process; and, (4) Develop independent learning: Use this code when the student is talking about independent learning while adopting the predefined pedagogical process.

Results

Tutors results

After the analysis of tutors' answers, Table 2 summarizes the result of the study. The overall usefulness and the number of sections is presented for the different processes. For each process, the table presents the number of sections according to their usefulness level. As shown in Table 2, overall usefulness of majority of the pedagogical processes is "often" (65%). For that, the mean of the overall usefulness is 2.37 and the standard deviation is 0.93. Moreover, 12.5% of processes have "always" and 21.875% of processes have "sometimes" usefulness. As a result of this study, it is observed that the usefulness of the different process sections is not "rarely". For the processes of two lesson, the mean of sections number by usefulness level and the standard deviation indicates that the usefulness of 57% sections is "often" or "always". For the first lesson, 22% of process sections have "always" usefulness and just 28% of process sections have "sometimes" usefulness. On the other hand, 18% of the process sections of the second lesson have "often" usefulness and 34% of the process sections have "sometimes" usefulness. For the two lessons, 28% of the process sections have "often" usefulness.

Students results

Learning performance

The pre-test scores of both groups (control and experimental) were analyzed using the two sample t-test which was reported as an effective statistical method to deal with limited sample size [40]. The obtained results showed that there was no significant difference in the pre-test performance of both groups since the p value was equal to 0.046 and greater than 0.005. To conclude, there was no significant difference in the prior-knowledge of spread management between the control and experimental groups before the beginning of the pedagogical process.

After the pedagogical process, the post-test scores were analyzed using the two-sample t-test. The obtained results showed that there was a significant difference in the post-test performance of both groups since the p value was equal to 0.003 and less than 0.05. Specifically, the experimental group achieved higher scores in the post-tests of spread management than the control group.

Learner motivation

Similar to the first analysis, the pre-motivation questionnaire scores of both groups were analyzed using two sample t-test. The obtained results showed no significant difference in the motivation levels between the experimental and control groups towards

Table 2 Usefulness of pedagogical processes

Lesson	Pedagogical process	Number of sections	Overall usefulness	Number of sections "Rarely" usefulness	Number of sections "Sometimes" Usefulness	Number of sections "Often" Usefulness	Number of sections "Always" Usefulness
Lesson A	P1	3	(Always: 3.67)	0	0	2	1
	P2	4	(Often: 2.25)	1	1	2	0
	P3	4	(Often: 2.75	1	1	0	2
	P4	3	(Often: 2.67)	1	0	1	1
	P5	5	(Always: 3.40)	0	1	1	3
	P6	5	(Often: 2.80)	1	1	1	2
	P7	4	(Sometimes: 1.25)	1	0	0	1
	P8	3	(Sometimes: 1.33)	2	1	0	0
	P9	3	(Often: 2.00)	1	1	1	0
	P10	5	(Always: 2.80)	1	1	1	2
	P11	4	(Often: 2.25)	1	1	2	0
	P12	6	(Often: 2.33)	1	2	3	0
	P13	5	(Often: 2.80)	0	2	2	1
	P14	4	(Often: 2.00)	1	2	1	0
	P15	3	(Sometimes: 1.67)	1	2	0	0
	P16	4	(Often: 2.75)	0	2	1	1
Lesson B	P17	4	(Often: 2.75)	1	0	2	1
	P18	4	(Always: 3.00)	0	2	0	2
	P19	5	(Always: 3.00)	1	2	1	2
	P20	3	(Often: 2.33)	1	1	0	1
	P21	4	(Sometimes: 1.75)	2	1	1	0
	P22	4	(Sometimes: 1.25)	2	0	1	0
	P23	5	(Often: 2.80)	0	2	2	1
	P24	5	(Sometimes: 1.60)	2	3	0	0
	P25	3	(Often: 2.00)	0	0	2	0
	P26	4	(Sometimes: 1.25)	1	2	0	0
	P27	6	(Often: 2.33)	1	3	1	1
	P28	5	(Often: 2.2)	1	2	2	0
	P29	6	(Often: 2.5)	1	2	2	1
	P30	4	(Sometimes: 1.75)	2	1	1	0
	P31	4	(Often: 2.25)	1	1	2	0
	P32	3	(Often: 2.00)	1	1	1	0
Mean of Sections Number by Usefulness Level 1 Sec				1 (0.94)	1 (1.28)	1 (1.12)	1 (0.71)
Standard Deviation of Sections Number by Usefulness Level				0.62	0.85	0.83	0.85
Mean of Sections by Process					4		
Mean (Overall Usefulness)					(Often: 2.37)		
Standard Deviation (Overall Usefulness)					0.93		

learning English vocabulary before the experiment. Particularly, the p value was equal to 0.35 and greater than 0.05.

After the pedagogical process, the post-motivation questionnaire scores were analyzed as well using the two-sample t-test. The obtained results showed that there was a significant difference in the post-motivation questionnaire scores of the two groups since the p value was equal to 0.02 and less than 0.05. Specifically, the experimental group had a higher motivation level towards learning spreadsheet management than the control group.

Learning achievement

To understand how the defined pedagogical process helped the experimental group achieving a better learning performance, the student was interviewed, and the given answers were qualitatively analyzed. The distribution rate of each coding item is presented (see Fig. 4). Specifically, it can be seen from these bar chart that the defined pedagogical process was more helpful for the student.

To better understand the obtained results of each coding distribution, the interview answers were analyzed and discussed as follows:

- *Identify learning obstacle*: The student reported that the provided recommendation in different sections of the pedagogical process helped him to identify the current learning obstacle. Consequently, it is seen that several students refer to the pedagogical process and then start to define the current learning weakness.
- *Give timely intervention*: As discussed in the first coding scheme, the proposed pedagogical process provided detailed performance to the tutor about solving the learning weakness of his students. Therefore, he provided timely interventions accordingly.

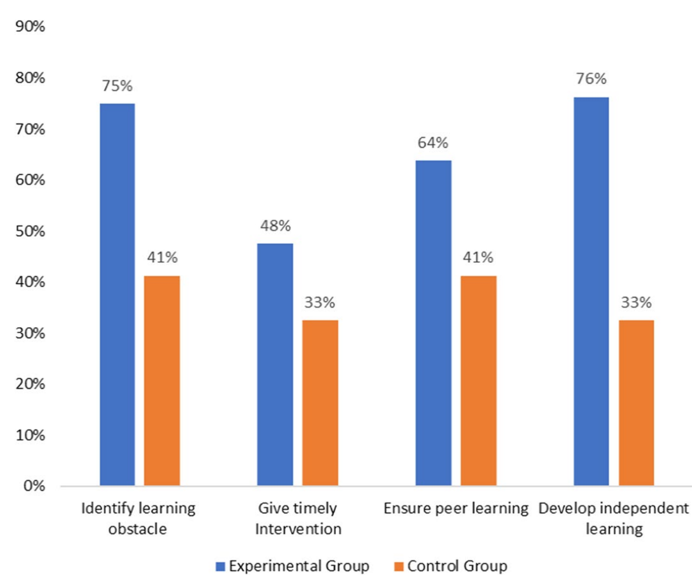

Fig. 4 Evaluation of interviews

- *Ensure peer learning*: The student mentioned that, from the provided well-defined pedagogical process, he could easily see that the limited inductive reasoning ability is considered. The student reported that the provided pedagogical process helped him to elaborate the desired learning level (individually or in groups). He also mentioned that the defined process supported him to find the concepts with different speeds of information processing (low, medium and high).
- *Develop independent learning*: It is evidenced that the provided pedagogical process made the learning reasoning very easy. The student however, mentioned that the pedagogical process, further emphasized associative learning by respecting the different skills. Consequently, it is seen that several students refer to the pedagogical process to consider their cognitive traits and then start learning independently.

Discussion

While prior research has developed predictive models of the educational process guidance, these models have historically dealt with learners, each of which may have same features for learning (Bayounes et al., 2013, 2014). We extend prior literature by finding that the important features associated with learner were related to cognitive traits, such as the memory capacity, their reasoning ability and the learning skills well as features related to their learning performance. These features may be relevant for selecting the appropriate pedagogical.

In this paper, we have demonstrated through a proof-of-concept study of cognitive trait of a learner, that a pedagogical process has to be appropriate, explainable and extensible. The concepts learned in this experimentation can be employed in other online courses. Through proof-of-concept "pedagogical process model" we have shown the importance of guidance in ITS however, there are significant hurdles before it can be realized in practice.

Feedback in guidance of pedagogical process is of utmost importance as evidences in our evaluation results. The tutor hence not only has to disseminate knowledge and skill, but also consider the individual cognitive traits of learner to offer the most appropriate recommendations. In fact, these initial results suggest automatically “select the most appropriate pedagogical process” questions may be a simpler task by using the intentional model than other adaptive learning tasks.

The proposed model was employed in a pilot study involving 40 students and 5 tutors, in the context of a spreadsheet certification course. However, there may be other relevant information that may be useful for pedagogical process guidance including data on personality type of tutor and pedagogical situation features, and, more broadly, data on tutor’s motivations and self-efficacy.

In particular, this section discusses the obtained results of study and their limitations regarding the guidance of educational processes. In fact, this study developed and validated an intentional model aware of learner cognitive traits for pedagogical process guidance. The first obtained results showed that the students who learned spreadsheet management using the well-defined pedagogical process achieved a higher learning performance. This can be explained by the automatically constructed pedagogical process by the intentional model aware of learning situation by defining the suitable intentions and the required strategies in a timely manner. From the pedagogical perspective, this study found that the proposed model can help the tutors to monitor their students whether they are learning individually or collaboratively, hence provide early interventions and support accordingly. The findings of this research could enhance the design of ITS by presenting a new process model that can be included in ITS architecture to help in guiding pedagogical process.

With regard to analysis of process sections, various scales were applied to evaluate pedagogical processes from the pedagogical reliability of tutor and the learning appropriateness of students. For the analysis of the scale "reliability level", we can see that the results revealed a high level of satisfaction among the different tutors. In fact, over 75% of the tutors say that they were happy, motivated and enjoyed the activity, and more than 80% felt relaxed and comfortable in the process.

For the students, the analysis of first appropriateness scale "learning performance", we can see that most students bring positive assessments regarding the consideration of this model as essential in developing learning performance, and regarding the importance in initial university training to work with intentional models, with positive values (agree or strongly agree) higher than 95%. The benefits of proposed model in initial tutor guidance also get positive values from over 90% of the sample. As for initial training and skills in this field, just under a quarter of the sample had worked with ITS; similar values are seen related to how to design learning activities in ITS.

With regard to second scale "learning motivation", we would point out that 100% of the students assess motivation improvement with positive values (agree or strongly agree). Over 75% of students also emphasize the collaborative advantages, skills development and educational innovation. And finally, more than 80% indicate that communication, cooperation and interaction in pedagogical process are positive aspects.

Regarding "learning achievement", the third appropriateness scale highlights that 100% of the students provide positive values regarding the view that the proposed model allows the problem identification to be easier. Over 85% of the sample believes that model permits active and timely intervention of tutors and that students ultimately learn. And more than 70% consider that engaging with the peer learning is better by using this model. Finally, over 90% of the students say that the proposed pedagogical process develops the independent learning.

Therefore, the values shown on the scales are quite positive, close to 90% on most sections of process except those referring to the experience of tutors in working with intentional model.

To address the first research question, which states: "What is the most appropriate cognitive trait model for pedagogical process guidance? The analysis of interview results proved that the cognitive trait model is most appropriate for pedagogical process guidance. The second obtained results showed that students who consider the pedagogical process had a higher motivation level. This could be attributed to use cognitive traits model.

For the second question, which How the cognitive trait model was considered by the intentional model for pedagogical process guidance? The material section illustrates the use of CTM as exploration argument of intentional model for pedagogical process guidance. Particularly, the results of tutor evaluation showed that the usefulness of proposed model is often.

For the third question, the different challenges are the improvement of learning performance, the enhancement of the learners' likeability and the tutors' satisfaction. In fact, the results of pre- and post- test proved the improvement of learning performance. The answers of interviews and the results of motivation test explain the enhancement of learners' likeability. Similarly, the different evaluation grids also showed that providing well-defined pedagogical process can positively affect the tutors' satisfaction.

The results of this study showed a "good" and "moderate" agreement degree in modeling pedagogical process compared to other studies (Bayounes et al., 2014; Tato et al., 2022). These findings support our hypothesis which suggests that the learners' traits can be considered by the intentional model for pedagogical process guidance.

Conclusion, limitations and future directions

Adaptive learning entails the largest portion of ITS research up until now. Given that our analysis accounts for all research from 2000–2022, there exists further opportunity for a dedicated analysis of the more recent years publications only, in order to form a better understanding of reasons for ITS research popularity, and identification of potential new areas of research within. Topics such as Educational process Guidance are clearly underrepresented and may deliver promising avenues of future research—especially as some of this research seems yet unpublished.

In particular, there has been a reemergence of ITS, which are gaining traction due to their ability to deliver learning resources and adapt to the individual learning needs of students and the pedagogical preferences of tutors. Yet, even though these systems meet students' needs and tutors' preferences, there is still a low number of implemented systems designed to address the cognitive problems faced by many students. To tackle this problem, this research proposes an intentional model that adopts Map formalism to support personalized pedagogical process guidance by considering cognitive traits of the learners.

Limitations

In this work, we explore the combination of CTM with intentional model for pedagogical process guidance to consider the individual cognitive features of learners. This new version of intentional model shows high efficiency. It will provide practical guidance for improving student engagement and motivation at different levels of education. The proposed model is evaluated in different learning situations of the MOS certification course to assess different model guidelines.

Given the limited number of participants, general conclusions can only be made with caution. However, the findings do suggest a valuable model for pedagogical process guidance in ITS. The preliminary evaluation shows that the proposed model can enhance learning level by considering different preferences of tutors and various cognitive traits of learners. However, there are two major constraints for the application of this model. The first one is the huge task that learners would need to undertake to respond to an explicit questionnaire for determination of their cognitive traits. The second constraint involves the elimination of some pedagogical preferences that makes the proposed guidelines less suitable according to the real pedagogical situation.

Moreover, some limitations are found which may limit the generalizability of the results. For instance, the sample size of the experiment was limited, due to the experiment context (public university). Also, the pedagogical process of each group (control and experimental) was only for two hours. However, despite these limitations, this study presented insights, including practical examples and recommendations.

Major findings

General findings from our intentional model of pedagogical process indicate research involving adaptive learning to comprise the highest volume of research overall. This area presents a high level of adaptivity of ITS, such as with research applying Recommender Systems in an adaptive manner, based on user input or trace.

The proposed model of pedagogical process combined with the cognitive trait model could constitute a solution to improve the adaptive learning in ITS. The core contribution of this research is to provide a suitable pedagogical process path by respecting the cognitive traits of learners and the pedagogical preferences of tutors. This contribution has attempted an optimization of intentional model for the pedagogical process guidance to support the adaptive learning by an ITS. However, the proposed model considers different definitions of the pedagogical process (Bayounes et al., 2014). It is based on a non-deterministic ordering of intentions and strategies (Rolland, 2007), that allows us to model the pedagogical process. Different progressions from one intention to another are guided by strategies (Velez, 2002).

Within this context, the proposed model adopts the CTM model to consider different cognitive traits of learners in the pedagogical process. Based on these aspects and different dimensions of individual teaching style or the corresponding pedagogical method, the model guides an adaptive construction of pedagogical process.

Future directions

Overall, this work can serve researchers in ITS by guiding the most appropriate pedagogical process which considers cognitive traits of learners and preferences of tutors. Future work lines include two main threads. On the one hand, this model can be a basis for integration of fuzzy logic in order to generate more suitable guideline according to the current state of cognitive traits and the dynamic pedagogical preferences. On the other hand, we have detected a clear need for providing the intentional model for pedagogical process guidance that considers personality type of tutor.

In addition, future research work could focus on making the pedagogical guidance smarter by designing a smart chatbot to provide interventions based on predefined model and different results of learning analytics techniques. In fact, future studies ought to focus on how to integrate these significate research results with development of appropriate models for educational processes guidance that consider various tutoring and learning disabilities.

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Declarations

Competing interests
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