Emotional States Management for an Advanced Intelligent Tutoring System

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Abstract: One of the result of the application of Artificial Intelligence (AI) to e-learning environments are Intelligent Tutoring Systems (ITSs). A crucial aspect in the field of e-learning concerns emotional states, which importance is increasingly felt also at the level of educational institutions. On the other side, the Management of moods at Information Technology level is becoming more and more important because enable new scenarios where new innovative applications can be proposed. In this paper is described a possible framework able to manage emotional states that could be adopted as a solution to address the *Personal, social and learning to learn* competence, one of the eight key competences lifelong learning indicated by EU COUNCIL.

1 INTRODUCTION

Intelligent Tutoring Systems, or ITSs, are a consequence of the application of Artificial Intelligence (AI) to e-learning environments. The ITS vision can be summarised as the creation of a personalised tutor for each student able to provide them with exactly the support they need to get the most out of their learning experience. Unlike a dedicated human tutor, the ITS would also be able to take into account many more parameters and data and thus be fully compliant with the goals and objectives (strict or otherwise) of each individual supported user. Being able to also report to the learner on the effectiveness and efficiency of the learning activities would increase his or her capability to acquire skills and/or knowledge. Students would also be empowered to share this information with their teachers, thereby enhancing teacher effectiveness. Recently, KEPLAIR (Knowledge-based Environment for Personalised Learning using an Artificial Intelligence Recommender) (Ferilli et al., 2021; Ferilli et al., 2022) has been proposed. It is an ITS designed to make pervasive use of artificial intelligence to perform its tasks. Although KEPLAIR was designed for independent learners, due to its advanced features it can also be used in contexts such as compulsory schooling to involve students in the choice of study materials and, as in the case proposed in this paper, in the choice of learning paths. Indeed, for some years, there has been an in-depth discussion at the European level on the subject of the skills that individuals must acquire in order to ensure their full development. This is a pivotal issue, with cascading implications that affect the issues of training, education and orientation towards work and social welfare. The result of this process was the elaboration of the eight European key competences, which the Member States of the European Union are called upon to transpose, facilitating their acquisition by all citizens. The reference text is the Recommendation on key competences for lifelong learning[1] approved by the European Parliament on 22 May 2018. The Reference Framework sets out eight key competences:

- Literacy competence,
- Multilingual competence,

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[1]UE, COUNCIL RECOMMENDATION of 22 May 2018 on key competences for lifelong learning - https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32018H0604(01)

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- Mathematical competence and competence in science, technology and engineering,
- Digital competence,
- Personal, social and learning to learn competence,
- Citizenship competence,
- Entrepreneurship competence,
- Cultural awareness and expression competence.

In particular, Personal, social and learning to learn competence is related to the ability to self-reflect, to manage time and information effectively, to work with others constructively, to remain resilient and to manage one's own learning and career. It includes the ability to deal with uncertainty and complexity, to learn to learn, to support one's physical and emotional well-being, to maintain physical and mental health, and to be able to lead a health-conscious and future-oriented life, to empathize and to manage conflict in an inclusive and supportive context. Emotional well-being is closely interconnected with the recognition of emotional states.

The objective of this position paper is to outline a possible IT framework able to manage emotional states that could be exploited as a solution for a practical case of implementation of the EU recommendations on key competences, the Italian case on PCTO[2].

2 BACKGROUND

In this section we report the related work and some specific prototypes implementation that will be used to implement the proposed ITS framework.

2.1 Related Works

The recognition of emotional states (also known as moods) falls within the scope of affective computing, an interdisciplinary research field spanning computer science, psychology, and cognitive science. Mood has a lower intensity but a longer duration than emotion since it is an emotional state that affects the experience and behavior of a person. To the best of our knowledge, unlike standard emotions where various approaches have been proposed (Imani and Montazer, 2019), (Yadegaridehkordi et al., 2019), framework proposal for the management of moods in education from IT perspective has not yet been investigated in depth. In (Abaalkhail et al., 2018) is presented a survey on ontologies for the representation of affective states and their influences including proposal for moods ontologies. Indeed, the paper denotes that there are only few ontologies proposal that target mood and human influence. In (Bolock et al., 2021) is proposed an interesting proposal of a psychologically driven ontology for describing human behavior based on character traits and states. The OWL ontology they propose highlights that taxonomic knowledge representation is not sufficient to fulfill the purpose. In fact, the use of Machine Learning methods to predict mental state rather than a Semantic Web Reasoner is adopted. The ITS framework we propose will work by applying multi-strategy reasoning rather than Machine Learning methods.

2.2 KEPLAIR

KEPLAIR is an ITS designed to act as a personalised tutor that helps learners find the tools, resources, experiences, and connections they need to learn exactly what they have chosen to learn. KEPLAIR's artificial intelligence engine will facilitates fine-grained personalisation for each user, taking into proper account the many aspects involved: learner's cognitive level, pre-existing knowledge about the topic, and preferred physical and social environments, needs, background, abilities, aims, interests, tastes, preferences, attitudes, behaviours, motivations, expectations, context, and community. KEPLAIR's recommendations might include books, audio files, videos, online courses, membership associations, community resources, or even other people. KEPLAIR can help students find their way both through predetermined curricula, and on their own educational goals. The system will pervasively use symbolic AI to carry out its tasks. Distinguishing characteristics and contributions of KEPLAIR are the extensive set of features it proposes, covering all aspects of the learning process. To ensure homogeneity and coordination among all of its subsystems and components, a crucial role is played by an ontology. It will act as a schema for the data that informs all the internal representations and behavior, so as to smoothly connect and orchestrate all the various functions and ensure both internal and external interoperability. In particular, interoperability with GraphBRAIN technology (detailed in the next subsection) is guaranteed since it has the same organization of knowledge (Ferilli et al., 2022). KEPLAIR was conceived with the aim of supporting students independently of educational authorities, although it can also be used to support teachers and education managers. Since one of the PCTO objectives is the

[2]Linee guida dei percorsi per le competenze trasversali e per l'orientamento (PCTO), MIUR, 4/9/2019 - https://www.miur.gov.it/web/guest/-/linee-guida-dei-percorsi-per-le-competenze-trasversali-e-per-l-orientamento

involvement of learners in the definition of learning path and in the choice of study materials, KEPLAIR seems well suited for this purpose as we explain in the proposed approach section.

2.3 GraphBRAIN

GraphBRAIN (Ferilli and Redavid, 2020a) is a general-purpose tool that allows to design and collaboratively populate knowledge graphs, and provides advanced solution for their fruition, consultation and analysis. The functions provided by GraphBRAIN bring to cooperation many different Artificial Intelligence tasks, techniques, and approaches for improving knowledge management and (personalized) fruition by users, including: database technology, ontologies, data mining, machine learning, automated reasoning, natural language processing, personalization and recommendation, collaborative and social interaction tools, and social network analysis. While most of these items are investigated and exploited separately in the state-of-the-art, the relevance of the GraphBRAIN methodology is in their being really integrated, and not simply juxtaposed, so that each of them takes directly or indirectly advantage from all the others. This allows GraphBRAIN to find relevant, personalized, and non-trivial information, e.g., a social approach is used to build and integrate ontologies; user models are used to guide data mining; ontologies are used to guide database interaction and interface generation; data mining is used to filter a manageable and relevant portion of a huge graph on which carrying out automated reasoning, etc. GraphBRAIN's functions can be used on-line, interactively by end users or delivered as Web services to other applications for obtaining selective and personalized access to the stored knowledge. For the formal representation of emotional states only a taxonomic representation model may not be sufficient, but more expressive models are needed. For this reason, GraphBRAIN was considered in this proposal. In fact, it supports multiple formal knowledge representation languages ranging from OWL (so it is possible to reuse existing ontologies) to FOL (more flexible for the representation of variable knowledge structures such as context- and situation-dependent ones).

2.4 WoMan

WoMan (Workflow Manager) (Ferilli, 2014) is a framework for workflow learning and management, based on First-Order Logic representations. Its process mining engine, applicable to activity logs coming from actual process executions, is able to learn models involving concurrent, repeated, optional and duplicate tasks in any combination, weighted elements. Its full incrementality avoids the need for having all the examples available from the beginning, still allowing the learning to start from scratch. Correct models can be learned using very few examples (in principle, any set of examples including at least one representative of each allowed process). It can also handle noise in a very straightforward, intuitive way. Finally, the representation language allows the description of not just the flow of events, but also the context in which the activities take place, and hence the learning of complex (and human- readable) pre- and post-conditions for the workflow elements. A relevant issue in Process Management in general, and in Process Mining in particular, is to assess how well can a model provide hints about what is going on in the process execution, and what will happen next. Indeed, given an intermediate status of a process execution, knowing how the execution will proceed might allow the (human or automatic) supervisor to take suitable actions that facilitate the next activities. The task of activity prediction may be stated as follows: given a process model and the current (partial) status of a new process execution, guess which will be the next activity that will take place in the execution (Ferilli et al., 2017). WoMan models can be used for the monitoring and supervision of processes and, when applicable, can be translated into standard representations (Petri nets). Both controlled and real-world experiments show that WoMan outperforms existing process mining systems in accuracy, effectiveness and efficiency. It ensures quick, correct convergence towards the correct model, using much less training examples than would be required by statistical techniques, even in the presence of noise. WoMan is currently being wrapped in a Web service that can be exploited by external applications for learning, simulation and checking of workflows.

3 AN APPLICATION CASE

3.1 EU Recommendation on Transversal Competences

The European Union has defined transversal competences as those skills that enable citizens to act consciously in a profoundly complex social context and to meet the challenges posed by increasingly digitised and interconnected organisational models. The European Council (with the Recommendation of 22 May 2018) summarised the transversal competences by specifying a comprehensive framework structured according to the specific competence elements. This

framework is organised according to four semantic areas and one in particular is related to emotional states:

- **Personal, Social and Learning to Learn.** Competence refers to the ability to manage one's own learning, to lead a physically and mentally healthy life, to create the right conditions to work well in a group, to act in complex situations and to manage interpersonal dynamics in an inclusive and constructive perspective.

Transversal competences are placed at the centre of the learning pathway because they improve the learner's degree of awareness of his or her own personal growth. At the same time, they activate reflective and behavioural skills that are essential for moving around in social and work contexts; in fact, they involve processes of thought and cognition, but also of behaviour. They are key competences in the perspective of lifelong learning because they are characterised by a high degree of transferability to different tasks and environments, thus equipping the learner with skills that enable him/her to improve the quality of his/her own behaviour and to implement effective strategies for the different contexts in which he/she will be acting. Furthermore, it is important to consider the importance of these soft skills also in a self-orientative function: the student must be able to obtain feed-back on his strategies and use them to reorganise his ability to orientate himself in different areas. In short, transversal competences enable the student to enrich his personal assets with knowledge, skills and attitudes that enable him to behave adequately and effectively in the complexity of the situations in which he finds himself.

The peculiar nature of transversal competences implies for the school an innovation in teaching methodology, oriented towards strengthening the connection between formal, informal and non-formal contexts in which learning takes place. The emotional and relational aspect is placed at the centre of the educational process and becomes a substantial element of lifelong learning. In the same way as the teaching methodology, the monitoring of the learning process, and thus the assessment tools, must also be adapted to the characteristics of transversal competences. Among other things, this also means organising and prioritising individual and group interviews, simulations and other active methodologies (role playing, project work, etc.) over 'traditional' forms of assessment. Assessment, in fact, no longer concerns only the goals and skills acquired, but also the degree of awareness acquired by the student, first and foremost in knowing how to judge and enhance his or her abilities in terms of transversal skills. Therefore, in line with the general teaching approach, the activation and participation of the student is also a central element for the monitoring and evaluation system of the training pathway.

3.2 Transversal and Orientation Competences

The EU recommendations have been implemented in Italy through Transversal and orientation competences (denoted as PCTO) guidelines. The main purpose of the PTCO is to make sure the student acquires the functional competences for the study pathway undertaken and the transversal competences aimed at orientation in the world of work or at subsequent higher education. This means covering the curricular, the experiential and the orientation dimensions.

Starting from this fundamental premise, the PTCOs can be develop with different organisational forms, not only according to the course of study or to the territorial specificity of the school, but also according to the personal needs of each student. Personalisation of the study pathway is an essential aspect because it allows the student to become aware and self-directed in defining his or her personal growth project. This is why it is possible to develop different types of PTCO within the same class group. Furthermore, it must be considered that the possibility of realising the pathway abroad is also envisaged, always as a function of an activity that is as coherent and functional as possible in relation to the student's specific pathway. For this reason, the programme presents multiple options with respect to the organisation with which the school can enable collaborations. In addition to public and private bodies, third sector and entrepreneurial entities are becoming increasingly important. Therefore, the design of a PTCO instance must have flexibility as a fundamental organisational criterion, but within a well-defined regulatory framework.

3.3 PCTO Roles and Evaluation

Fundamental to the success of a PTCO is the role of the disciplinary departments, whose task is to ensure consistency with the three-year Education and Training Offer Plan as prescribed in Italy. However, it is the Class Councils that design (alone or in collaboration with the external body) the pathway, manage the activities and carry out the final assessment. In fact, first the Class Council selects the competences for the class group, then each individual teacher must identify (from among these selected competences) the specific ones that he or she considers functional to his or her teaching. The careful selection of the com-

petences to be developed has a fundamental importance. It must allow for student self-direction, involving them already in the planning of activities and stimulating their reflection and active participation. Similarly, communication with families, documentation of all the stages of the pathway and sharing the results of the experience are critical for the outcome of the PTCO. Finally, it is essential that the school institution moves towards co-design involving the external parties in defining the objectives and educational methods in that cases when the project is carried out in collaboration with a third party.

Coordination between the parties involved is performed by the tutor, who is appointed by the educational institution to perform certain functions that are fundamental for the implementation of the pathway. In addition to the coordination between the school institution, the third parties involved and the family, the tutor constantly monitors the development of the activities, provides assistance to the student and informs the school institution of any critical issues. He/she is a crucial figure because he/she plays a managerial and supportive role, which fosters the creation of the right context for achieving the planned goals. If provided for in the PTCO project, the internal tutor may be supported by an external tutor selected by the host organisation. This figure is the student's referent within the organisation where the training activity takes place, but also acts as a link between it and the educational institution. He/she is therefore expected to maintain a constant liaison with the internal tutor. The interaction between the two tutors, who must be selected on the basis of appropriate training skills, is a key factor for the success of the course.

The evaluation of the PTCO should assess the process and the end result. In this way, it is not only the objectives achieved that are assessed. Through the structured observation of the entire process, the acquisition of transversal competences is also assessed, giving importance also to character and motivational aspects.

The most frequently used tools for participative observation are rubrics, diaries, digital portfolios and observation sheets. The final results, on the other hand, are evaluated in several stages, ranging from the identification of objectives to the verification of the content learnt during the course. Obviously, the observation of the entire process (carried out by the tutors) influences the evaluation of the final results, which is, however, done by the teachers of the class council and affects behaviour and the final score. Lastly, it should be emphasised that PTCO activities must be included in the student's curriculum, the document that is attached to the final diploma to certify the skills acquired by the student along the course of study.

4 PROPOSED APPROACH

4.1 Approach Steps

In this section, we report how the proposed framework works identifying how the prototypes implementation will be used. In detail, three phases can be identified:

- Uploading content into KEPLAIR. In this phase the school institution uploads, if not pre-existent, the content that it considers to be useful for the specific transversal competences pertaining to the institution itself. This content will enrich the material contained in KEPLAIR and will remain available to the entire community that will use it.
- Creation of the PCTO project. As prescribed by the PCTO guidelines, a learning pathway that will be assessed by the school institution must be created. In this phase, the active involvement of the student is explicitly stated in the EU recommendations. The student will then use KEPLAIR independently obtaining the possible learning paths. The material to be studied suggested in a learning path may or may not include the material uploaded in the previous phase by the institution. In fact, KEPLAIR will determine to recommend or not the institution contents by applying its AI approaches on the whole material available in its knowledge base. Finally, the student will discuss with the tutor the choice of pathway to be submitted for approval by the educational institution from among those suggested by KEPLAIR. The approved learning pathway will be semantically formalised through a process specified in the WoMan formalism. In this process there will be the basic workflow represented by the chosen learning pathway and some features chosen by the institution useful to monitor learning progress in accordance with PCTO guidelines. In particular, these features will include those related to personal, social and learning to learn skills specified in the section 1.
- Course delivery. During the delivery of the content, physical or virtual sensors, part of the WoMan process, are used to detect values useful to establish the mood of the learners. These values are stored in the graph DB managed by GraphBRAIN. This tool is enabled to manage these data semantics by means of an ontological representa-

tion that allows either taxonomic (e.g., OWL) or more generic (e.g., FOL) representations. As stipulated in the PCTO guidelines, the learning path is evaluated at precise points of the activities to be performed and also takes into account the moods of the learners useful for monitoring the learning progress. Since the semantics of all this information can be interpreted by GraphBRAIN, anomalous situations can be detected applying the multi-strategic reasoning (Ferilli and Redavid, 2020b). In this case particular information will be communicated to KEPLAIR that will modify the suggested learning path. As consequence, the material that was suggested to the learners and approved by the teachers can be modified in order to improve the learning outcome (e.g. if GraphBRAIN detects a certain discomfort in the student since supplementary material in Maths has been assigned than KEPLAIR suggests alternative supplementary material). In addition, the supervision functionality offered by WoMan will make it possible to assess whether the specific student is correctly following the process formalised for him/her in the previous phase. Through this monitoring, corrective actions can be taken in accordance with the tutor in order to have a better result of the student's learning performance.

5 CONCLUSIONS AND FUTURE WORKS

The ITS meta-analytic review presented in (Kulik and Fletcher, 2016) has proved their efficiency with respect to other forms of tutoring. As the authors themselves indicate, it is not easy to determine what the next generation of ITS will look like, but they will certainly be influenced by three factors: computer hardware, software, networking, and *cognitive science*. In this paper we have outlined a possible framework that can also handle the moods represented by learning processes formalised in the WoMan formalism. Furthermore, through GraphBRAIN it will be possible to handle different knowledge representations and apply multi-strategic reasoning in order to improve students' learning performance. In addition, by using KEPLAIR we are able to cover one of the fundamental requirements of PCTO: empowering students by allowing them to create proposals for learning paths. As future work, a comparison with realities outside the European community is desirable. In particular, we have planned to test the platform in the Ukrainian context with the support of the T.H. Shevchenko National University "Chernihiv Colehium". On the one hand, the sharing of EU recommendations can be an opportunity to bring these two realities closer together; on the other hand, the current difficult situation requires a massive use of online tools for school education. Also if any e-learning has different goals (Matviichuk et al., 2017), the deeper use of modern technologies, namely elements of the artificial intelligence (AI) proposed in this work, could be reveal new modality to use an intelligent learning system (ITS).

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