colMOOC™

D6.3 Policy recommendations

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The colMOOC:

Integrating Conversational Agents and Learning Analytics in MOOCs

D6.3 – Policy Recommendations

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Executive Summary

This report discusses recommendations made to the different stakeholders involved in the adoption of Conversational Agents to set up learning discussions. These recommendations derive from the creation of agent and learning analytics technology, its integration with three different learning platforms and its evaluation along many pilots, which have been carried out in the project. Educators and instructional designers are advised to think about the design of CA-mediated debates at course level (their role in the course), task level (how they can foster productive conversation) and at the interaction level (how their interventions promote the desired skills). Technology providers should aim at a seamless integration of the agent chat with the learning platforms, keeping the educator in charge of defining the agent behavior, as well as connecting learning analytics from both technological platforms. Institutions should consider these activities not only in large scale courses. Finally, policy makers are recommended to promote the use of CA technology in formal education, especially in relation to the development of critical thinking and reasoning skills. They are also encouraged to look at the ethical implications of using human sensitive data, such as conversation, to intervene in the learning process and analyze it.

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List of Acronyms

Acronym	Description
MOOC	Massive Open Online Course
SPOC	Small Private Online Course
CA	Conversational Agent
APT	Academically Productive Talk
LTI	Learning Tools Interoperability
REST	Representational State Transfer
API	Application Programming Interface
xAPI	Experience API
AUTH	Aristotle University of Thessaloniki
UVA	Universidad de Valladolid
UOC	Universitat Oberta de Catalunya
AU	Aarhus Universitet
SU	Saarland University
CERTH	Center for Research and Technology Hellas
GUNET	Greek Universities Network

1 Introduction

1.1 Purpose of this document

The colMOOC project aimed at promoting the use of Conversational Agents to support collaborative learning activities in MOOCs (Demetriadis et al., 2021). Such use is different from all other uses of chatbots or conversational agents in education, which have been applied at small (see for example Tegos, S., Demetriadis, S., Karakostas, A., 2015) and large scale (Catalán-Aguirre et al., 2021), but always in one-on-one configurations, i.e., with only one student establishing a dialog with the agent, instead of chatting with a peer with the mediation of an agent. The sole application of Conversational Agents in groups of learners besides the colMOOC project is, to the best of our knowledge, the DANCE project, which used chatbots to support social interaction in MOOCS (Rosé & Ferschke, 2016). Note, however, the difference with the colMOOC approach, where agents aim at both social facilitation and cognitive support in collaborative learning (Michos et al., 2020). Another differentiating aspect of the colMOOC project has been the support for educators, so that they may define the desired behavior of the agents in their learning scenarios, thanks to the agent editor (Demetriadis et al., 2021; or see deliverable D2.1 for details). All these aspects have allowed the project to collect valuable insights that can advise instructors on the design of learning experiences supported by Conversational Agents.

Along the project, the colMOOC technology, consisting of an agent editor and an agent player, has been seamlessly integrated in the three technological platforms of the three course providers participating in the project: MiriadaX, the leading platform in MOOC delivery for Spanish-speaking learners, owned by Telefónica Educación Digital; eClass, a learning platform developed by the consortium of all 25 Higher Education institutions in Greek (GUNET); and Learnworlds, a platform to create and sell online courses offered by the company with the same name. The experience of these technological integrations (see deliverables D4.5 and 4.6) and the exploitation of the colMOOC tools in production during the pilots (see deliverable D5.3) have also allowed the consortium to come up with relevant reflections for courseware providers.

The academic partners of the project (AUTH, UVA, UOC, AU and SU) have designed and run multiple pilots of different nature (including some hybrid experiences, where part of the students were online and part of them face to face, and also pure MOOCs enrolling thousands of students with a traditional video and quiz design). A number of lessons learnt can also be derived for course providers (typically universities) from the experiences of the project, reported preliminarily by Demetriadis et al. (2021) and in full in deliverable D5.3.

In addition, the partner providing the colMOOC platform (CERTH) has adapted its functionalities and technological choices responding to the pedagogical needs of the pilots and the integration issues with courseware providers. The reflections on strengths and points to improve have been also collected to inform the design of future Collaborative Conversational Agent technology.

Finally, the experience accumulated in the project by partners of different nature is distilled together to make recommendations for policy makers shaping the evolution of education in Europe, on the ways that Conversational Agents could support the development of critical skills in formal education.

Therefore, this report collects recommendations derived from the project experiences that can be addressed to the different stakeholders involved in introducing conversational agents to support collaborative learning at large scales: educators/instructors, courseware providers (i.e., those with

the platforms to deliver courses), course providers (e.g., universities) and agent technology providers.

1.2 Document structure

- The present deliverable is split into the following major chapters:
- Section 2 collects the main recommendations for educators and instructional designers that may want to design CA mediated learning activities.
- Section 3 describes the recommendations for providers of technology, both courseware and agent tools.
- Section 4 gathers the most relevant recommendations for course providers, like universities and other educational institutions.
- Section 5 distills some recommendations for policy makers in the domain of education, concerning the consideration of Conversational Agents in formal learning to develop key skills.
- The final section 6 presents brief conclusions regarding this deliverable.

1.3 Audience

This document is released to be public.

2 Recommendations for educators and instructional designers

This section reports the main recommendations for educators and instructional designers interested in using conversational agents in their courses. The recommendations derived from a set of preparatory pilots (small experiences with Conversational Agents before the MOOCs delivered by the project) and from the actual pilots of the project. In particular, initial learning activities with conversational agents were designed and tested at a small scale with university students (outside of a MOOC platform) in order to test the tools developed in the colMOOC project, as described in deliverables D4.2 and D4.3. This informed the final design of conversational agent activities for the MOOCs offered in the colMOOC project. For instance, in the case of the Spanish MOOC, the practitioners, namely the course educators, tested the colMOOC editor and player in a small scale study to gain hands-on experience with the design of collaborative tasks that include agent support and to receive feedback from students who perform these activities (Michos et al., 2020). This initial phase was particularly useful in order to prepare the learning activities for the MOOC that included collaborative tasks with agent support at a massive scale, and helped to ensure that MOOC participants have better learning experience with agents.

During the multiple pilots carried out, different types of data were collected and analyzed with the aim to extract recommendations for instructors and educators (for more details, in deliverable D2.2 we report the deployment and configuration of the Conversational Agent module, while in deliverable D5.2 we recount the collected data). The recommendations are presented at three levels: at the course design level (macro level); at the task design level (meso level); and at the agent interaction design level (micro level). The course design influences educators' decisions for the task design and accordingly their decisions related to the agent interaction design. The fact that recommendations at the inner levels are affected by others is graphically depicted in Figure 1.

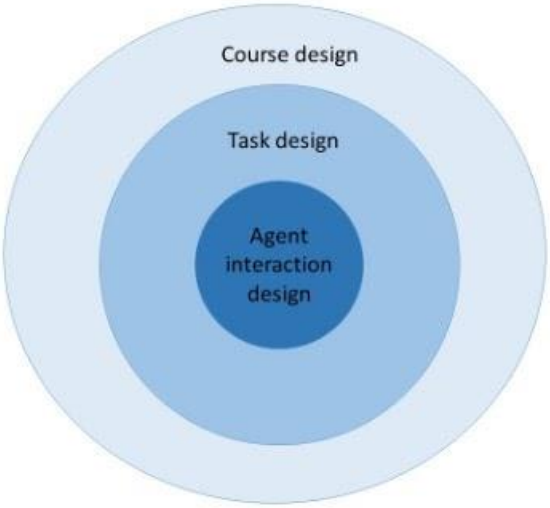

Figure 1: Three levels of recommendations for educators and instructional designers related to the integration of learning tasks with conversational agents.

The recommendations regard mainly the integration of collaborative tasks mediated by conversational agents in courses, because these types of tasks were tested and evaluated during the colMOOC project.

2.1 Course design level

The main recommendations at the **course design level** that includes learning tasks with conversational agents are the following:

- Educators need to conceptualize the connection between **the main competencies** promoted by their course e.g., general competencies such as promotion of collaborative and critical thinking skills and domain-specific competencies like skills for programming. The challenge is to fit and situate the corresponding agent interaction and task design to the overall competencies promoted in the course.
- Educators need to pre-evaluate the **overall workload of the course** and the required time to perform the collaborative tasks with conversational agents so that a good balance between the overall study during the course and practice is acquired. For instance, an estimated 1 hour of work for a synchronous collaborative task with the support of conversational agents in a MOOC should take into account the workload of the other learning tasks in a specific MOOC week and the rest of the course.
- Educators need to conceptualize **the structure of the learning tasks** included in the design of the MOOC course and purposefully situate their learning tasks with conversational agents in the overall course structure. For instance, a collaborative task with conversational agents might be used after reading a case study in order to connect theoretical concepts with the case study materials, and initiate a conversation that an agent orients or helps the learning partners to reflect on the domain concepts.
- Educators need to identify **key domain topics** that are important for further reflection and meaningful for a collaborative task with conversational agents.

2.2 Task design level

Concerning the **task design**, for collaborative learning tasks mediated by conversational agents, the following recommendations should be considered:

- A variety of **task types** is possible for collaborative tasks with conversational agents. Educators need to decide on the openness of the tasks, as described in deliverable D3.1 (section 6.1) e.g., discussing a case from multiple perspectives and agree on their main conclusions or solving a mathematical problem with a specific solution. One interesting approach to consider is selecting task types according to a collaborative problem solving design that, on the one hand, seek to promote students' collaborative skills and, on the other, their cognitive skills. The challenge is to design agents that would be able to tackle the openness of the task e.g., when discussions evolve agents should be able to identify key reflection moments to intervene, but also agents that promote the collaborative and cognitive skills or learning goals of the task.
- Educators need to design **challenging tasks** that are both meaningful for collaboration between two partners and, at the same time, require further reflection for learning with agent support. For instance, a challenging task might include two partners who should negotiate the main challenges of technology integration in schools by providing theoretical arguments taught during a course.
- Educators need to design tasks that take into account a **selected domain topic** (perhaps a key topic taught during the course) and a corresponding **agent behavior** according to the

task objectives. For instance, an educator might design a task that includes the topic of "computational skills" and adjust the agent so that it provides related key concepts, or challenges students to negotiate their opinions.

2.3 Agent interaction level

Finally, the fine grain level of design concerns the decisions of the types and specific interventions of the agent, i.e., the **agent interaction design**. Here, the following recommendations have been found relevant:

- Educators need to decide on the different **roles of the agent** during the chat discussion. One role might be an agent that prompts students to further reflect on their arguments; another role might be an agent that orients learning partners during group discussion similar to the role of a moderator in a panel debate. Another approach would be to restrict the agent to promote social interaction, without emphasis on supporting cognitive processes.
- Educators need to understand the **properties of conversations** promoted with conversational agents. For example, in the colMOOC project, agent design was theoretically based in the Academically Productive Talk (APT) framework, aimed at facilitating quality discussion and reasoning, as explained in deliverables D1.2 and D2.1. Accordingly, educators have the option to design agents that promote APT moves and select predefined agent interventions (e.g., AddOn, BuildOn) that will be displayed as a message during student discussions. After evaluating and learning more about the educational qualities and retrospective learning outcomes of the APT moves, educators can better select the appropriate agent behavior. This approach could be also extended with other teaching-learning frameworks that can be operationalized towards defining agent behaviors configurable by teachers.
- Educators need to decide on the **agent behavior**, which could be a single behavior or composed of multiple ones. For instance, a single agent behaviour is an agent that introduces new concepts to the discussion and helps students to brainstorm for a particular domain concept. Multiple agent behaviors might include an agent that introduces new domain concepts and an agent that asks partners to agree or disagree on their arguments. The key recommendation is that educators should pre-evaluate whether a single agent behavior is relevant according to the task design or whether multiple agent behaviors are needed. In the case of the former, educators should also decide how the different agent behaviors will be combined according to the task design and the domain topic that they selected (Michos et al., 2020).
- Educators need to decide on the lower granularity level of the agent interaction design which is the **final message** displayed during chat discussion. For instance, one type of message is a question that requires an answer from the learning partners whereas another type is a message that provides a hint to the learning partners. This is also similar to the convergent and divergent agent interaction design described in Demetriadis et al. (2021) and deliverable D5.3.
- Educators need to decide on the key domain and the **words or phrases** that will trigger agent interventions during discussions. These words might refer to synonyms that are very likely to be exchanged during student discussions or words extracted from the key materials of the MOOC course (e.g., readings, videos, quizzes). Another approach is to use antonyms instead of synonyms and try to trigger some cognitive conflict between the learning partners.
- Educators need to pre-evaluate the **cognitive or collaborative load** that is promoted with the use of agents. For instance, certain agent messages like questions might require high cognitive load and time, and thus they may be detrimental for the negotiation of the

patterns towards a common solution. In another case, an agent might serve as an orchestrator who helps learning partners merge their solutions to a given problem and reduce their collaborative load.

- Educators finally need **to inform the students about their interaction with the agents** before performing the activity (Demetriadis et al., 2021) This will help students to understand the learning benefits of interacting with agents and the different agent roles during their discussions.
- In addition, before the run educators should reflect on **which Learning Analytics indicators are more informative** of the progress of their students along the agent-mediated tasks they have planned, to track them during the enactment.

3 Recommendations for technology providers

This set of recommendations are targeted, on the one hand, at those providers offering a tool to create and run a discussion activity mediated by a Conversational Agent and, on the other hand, at those that run virtual learning platforms (be they at MOOC scale or smaller). They both need to work closely together so that the discussion activities are dealt with as any other learning activity on the platform, like watching a video, answering a quiz or taking a poll. Here are the main recommendations after the integration efforts carried out in the colMOOC project and pilots that were run on them:

- The colMOOC technical partners achieved the seamless integration of both the agent editor and the agent player in three learning platforms: MiriadaX, eClass and Learnworlds. This means that an instructional designer can create a CA-mediated activity using the bricolage design approach (Prieto-Santos et al., 2013), i.e., by using the graphical interface of the learning platform to create a configure new learning activities, be them a video, a quiz or a chat debate with the mediation of a CA. Similarly, students access the planned learning activities through the same interface, normally one that shows the list of modules and tasks and lets them access the associated resources. **This seamless integration has been highly valued by both instructional designers and students, and should be pursued for other learning platforms**, particularly widespread VLEs (Moodle[2], LAMS[3], Blackboard[4], Canvas[5], etc.) and other MOOC platforms (OpenEdX[6], for example, that is open source and is installed in over 1,500 sites[7]). Currently, the colMOOC tools are exposed through a REST API (see deliverable D3.1). Despite the wide acceptance of REST architectural style (Fielding, 2000), this still requires to program code in the learning platform, and thus the process of performing an ad hoc integration in each of them is very costly. An alternative approach would be to make the colMOOC tools conform to the Learning Tools Interoperability (LTI) specification[8], a standard that has been widely adopted for the integration of third-party tools into learning platforms (it is supported by all the aforementioned platforms and many others). Therefore, **it is recommended to refactor the colMOOC and other CA tools to be integrated in multiple learning platforms using the LTI standard**.
- The learning analytics dashboard derived in the project was indeed useful, especially for educators, to track the progress of the CA-mediated activities and provide (via an alternative channel, typically a post in a discussion forum) advice to improve the experience. However, currently the learning analytics provided by the learning platform (be it MiriadaX, eClass or Learnworlds) and those offered by the colMOOC analytics module are not integrated together (the latter can be checked within the learning platform, but the data of what students did in, for example, quizzes, videos and other learning

[2] https://moodle.org, last visited: March 2001.

[3] https://lamsfoundation.org/, last visited: March 2001

[4] https://www.blackboard.com, last visited: March 2001

[5] https://www.instructure.com/, last visited: March 2001

[6] https://open.edx.org/, last visited: March 2001

[7] https://trends.builtwith.com/cms/Open-edX, last visited: March 2001

[8] https://www.imsglobal.org/lti, last visited: March 2001

resources of the MOOC platform is not processed alongside with the data of what they did in the CA-mediated chats). As part of a richer integration, **the agent providers could expose (of course to GDPR-compliant properly authorized learning systems only) student log data of their actions in the chats, by means of popular standards like xAPI[9] or Caliper Analytics[10], so that they can be integrated in the analytics of the learning platforms**.

- The colMOOC approach for enacting learning debates with the mediation of a Conversational Agent has been to carry them synchronously, though a chat service. The alternative would have been to perform the debates asynchronously, in the form of a private discussion forum. Though both approaches can have their pedagogic benefits, synchronous discussions fit better with the theories of Academically Productive Talk (Adamson and Rosé, 2013), as many interactions are exchanged in short periods, creating the feeling of building knowledge together, as the discussion progresses, resembling more a face to face debate (Tegos, Demetriadis, and Karakostas, 2015). In this sense, for many students participating in MOOCs synchronously are more engaging as they help to build a sense of community, since during a period learners work intensively with a colleague. The choice of holding synchronous CA-mediated activities, however, has a very important drawback in true MOOCs with thousands of students distributed around the globe: getting a suitable partner to discuss at the same time. In the most massive colMOOC pilots, those carried out in Spanish through MiriadaX, both effects have been quite noticeable in the surveys performed: **students greatly valued the fact of discussing with a fellow student and the tips provided by the agent but, at the same time, complained about the difficulties to find a partner**, which in some cases forced them to connect several times in the day until another user connected at the same time. In smaller and more homogeneous courses, like the pilots carried out by AU, SU and AUTH, social arrangements through second channels (forums, email) or the instructor setting a fixed time to do the activity were valid solutions. In the larger pilots by UVA and UOC through MiriadaX, a mixture of these approaches was followed (setting not one, but a few time slots a priori convenient for different time zones, and encouraging to advertise alternatives in the forums) achieved only moderately satisfactory results. Therefore, **alternatives to set up the synchronous activities should be considered and given appropriate technological support**. Here are some potential approaches that need to be considered:
    - **Create means of booking partners and/or slots integrated in the learning platform**. These solutions could be integrated with the agenda students typically have in the learning platform, that also sends them reminders by email or in the mobile app associated with the platform.
    - **Carry out the CA-mediated discussions in messaging mobile apps that are commonly used by students**, like Telegram or Whatsapp. Normally, they pay attention to the notifications of such applications. If they join a "lobby", ask for a partner, and then receive a notification when a partner is available (maybe some time later), chances that the conversation takes off are much higher than if the students need to be waiting in a Web application for a partner.
    - **Change to fully asynchronous discussions, like forums**. It should be noted that agents should be seriously redesigned, as discussions in forums normally take just a few, more elaborated posts, as compared to many simple sentences in

[9] https://xapi.com/, last visited: June 2001

[10] https://www.imsglobal.org/activity/caliper, last visited: June 2001

chats. Agents will have less opportunities to intervene, and it is more likely that the discussion turns to be asymmetric, with one student interacting with the agent, while the other is passive.

- One of the most valuable features of the colMOOC approach is the enactment of teacher-configured conversational agents. In other words, teachers can define the behavior of an agent: what will trigger its interventions, the nature of the intervention (whether it is directed to one particular student or not, what APT move it implements) and even the detailed text of the intervention (so that, for example, it can be customized to more prescribed or casual learning settings). In summary, **educators can completely define their agents without the intervention of any technicians**, and without the collection of previous conversation data. This flexibility has allowed the definition of more than a dozen of different agents in the colMOOC pilots. This freedom for educators comes at a cost, though, namely the quality of natural language processing of these agents is lower than other tools, especially in the Customer Management Systems (for a review, see section 2.2 of deliverable D.1). These latter chatbots are often developed *ad hoc* to advise on a specific topic, and they often use machine learning techniques trained on a set of previous conversations, or other natural language processing techniques fine-tuned for the topic of interest. However, there is space for research in order to, **without compromising the flexibility that educators are who define agents' behavior, improve their quality of natural language processing**. This can be done by integrating libraries of natural language processing that are not dependent on the topic, when developing the agent. This improvement will avoid some awkward interventions of the agents when, for example, a polysemic term is detected in a use different that the one intended. It will also simplify the creation of agents by educators, as synonyms and alternative spellings will be dealt with by the agent logic directly.

4 Recommendations for course providers

In the project, academic partners offered several pilots that were conceptualized in different ways. This experience can help to inform the decisions made by institutions on whether to introduce Conversational Agents in their offered courses. Here are some relevant ideas:

- There were courses that were created from scratch to be run like MOOCs, following their traditional structure of videos and quizzes, and the introduction of synchronous debates to be mediated by Conversational Agents. **In large scale courses, CA-mediated debates enable active learning in activities in which students feel that they receive feedback**. They also allow building a sense of community, breaking the feeling of isolation typical of MOOCs.
- Other courses originated from the structure and content of presential courses, but were totally recreated online. In them, **Conversational Agents replaced debates that otherwise would happen face to face with the mediation of the teacher**. It has also to be considered that when delivering online courses to an homogeneous set of learners (e.g., a summer semester of a University), some of the problems of synchronous debates may be much milder: arranging pairs can be easy and students may even know each other from other contexts.
- Some other courses were delivered in hybrid modes (some students physically present and others connecting from home; some activities in the class and some online). **Conversational Agent mediated debates bring together students in different contexts, and can also help to put in practice the lectures, serving as a collaborative homework assignment**.
- In other concerns, institutions wanting to adopt the use of Conversational Agents should encourage their instructors to join Communities of Practice around the topic, either in-house communities formed only by members of their staff, or global communities like the one promoted by this project. The participation of instructors in Communities of Practice allows them to get in touch with enthusiast early adopters and learn quickly from their experiences (Hung, Lee and Lim, 2012).

5 Recommendations for educational policy makers

All previous recommendations are directed to stakeholders directly involved in setting up and delivering learning courses with Conversational Agent mediated debates: educators and instructional designers, technology providers and institutions offering courses. All these stakeholders have been represented in the colMOOC consortium in the preparation, realization and evaluation of the pilots. Beside the already described suggestions for other individuals and institutions adopting CAs in their educational processes, some recommendations are derived for policy makers in charge of shaping the education of the future:

- MOOCs are not normally part of formal learning curriculum, but rather they constitute another type of educational offer aimed at long life learning. However, SPOCs and remedy courses that follow a MOOC structure and are supported by MOOC platforms are more and more frequent at universities. In addition, as said in the previous section, CAs have shown potential not only in purely online massive education, but also in blended, smaller case settings. Hence, the benefits observed in our pilot studies at massive scale could be potentially transferred to other smaller contexts (e.g., SPOCs), thus suggesting that **introducing Conversational Agents discussions as a form of pedagogical approach in formal education would be beneficial**. In fact, the most recent "Innovating Pedagogy" report by the Open University of the UK (Kukulska-Hulme et al., 2021) suggests using chatbots alongside teachers in both formal and informal education to solve several educational problems.
- The Digital Education Action Plan for 2021-2027[11] aims, among its priorities, at fostering the development of a high-performing digital education ecosystem, which includes four requirements, one of them being "high-quality learning content, user-friendly tools and secure platforms which respect privacy and ethical standards". **Conversational Agents are user-friendly tools that help to develop and enhance both cognitive and social skills of the learners, and should thus be promoted in such plans, as part of the digital education ecosystem**.
- There is a growing consensus that critical thinking and reasoning skills are crucial so that citizens are prepared to respond to the social and economic needs of the 21st century (Ananiadou & Claro, 2009). This has led to initiatives researching how to foster them in all education periods, like the Erasmus+ funded project CRITHINKEDU[12], focused on their promotion in Higher Education. This project has developed a protocol for fostering critical thinking based on the premises that students develop their critical thinking by explicitly engaging in appropriate learning activities, and becoming stronger in critical thinking requires repeated engagement in critical thinking processes (Ellen et al., 2019). The protocol defines goals, conditions and supportive interventions to achieve the development of this skill. For the latter it specifies that "*inducing critical thinking implies that open questions are raised, ill-structured tasks are provided, complex problems are discussed and/or authentic, real-world issues remain at the core. What 'inducing' entails and how it can be done may vary for different fields and disciplines and may be done in different ways*" (Ellen et al., 2019). These features match very well the pedagogical affordances of Conversational Agents, and fit in the colMOOC approach of letting

[11] https://ec.europa.eu/education/education-in-the-eu/digital-education-action-plan_en, last visited: March 2001

[12] https://crithinkedu.utad.pt/, last visited: March 2001

instructors customize the agent behaviour. Further, they study the role of peer interaction in the development of Critical Thinking, though here the results are mixed (Domínguez, 2018): some studies showed no significant effect while others revealed more elaborated justifications of arguments after discussion with peers. While the reports of the project elaborate on the importance of adequately designing the learning environment (defined in a broad sense), the potential of computational tools to support peer discussion with the aim of developing critical thinking is not explored. We believe **fostering critical thinking and reasoning skills should be keystones of educational designs and that Conversational Agents are adequate tools to support many learning activities with this goal**.

- Based on ColMOOC results (see deliverable D5.3), the use of conversational agents in debates with a peer has been appreciated by learners. However, the successful implementation of CA-mediated learning activities requires that educators be aware of the benefits and risks of using conversation agents, and therefore educators should consider several lessons learnt, as the recommendations presented above**. Policy makers should consider including comprehensive support to educators in their professional development programs concerning the design of CA-mediated debates**, and further study the innovative uses of CAs in educational practice. Besides, the creation of cross-institutional Virtual Communities of Practice (see deliverable D6.2), concerning CAs but also other innovations in Technology Enhanced Learning, should be promoted by policy makers, as an instrument to spread and discuss good practices among educational practitioners.
- Besides the inclusion of Conversational Agents, the increasing growth of Learning Analytics should bring the attention of policy makers. There are many concerns that are generic and not specific to CA-mediated debates, like privacy, ethics in development and use of indicators and a vision to put humans in the center complementing numerical data with other ways of understanding the learning process. This has already been reflected in the European Union High-Level Expert Group on AI released its report on "Ethics Guidelines for Trustworthy AI" (Directorate-General for Communications Networks, Content and Technology - European Commission, 2019). Similarly, **the use of data from live conversations to trigger agent interventions**, and later on to analyze their impact, has an immense potential to improve the learning experience but **should as well be reflected on, considering the ethical implications this may have**.

6 Conclusions

The colMOOC project has developed agent editing and execution technology, as well as an associated learning analytics tool; it has integrated them into three different learning platforms; and it has evaluated the resulting ensembles into a series of pilots with different specificities. From the accumulated experience, recommendations have been made for the relevant stakeholders. Advice for educators and instructional designers allows to think at course level (what is the role and the impact of CA-mediated debates in the course), task level (how should the task be formulated to achieve a lively and productive conversation) and at the interaction level (what role will take the agent in the debate, how its interventions of the agent should be designed in detail to promote the desired skills, and how they could be monitored through learning analytics). Technology providers offering the agent editor and player, and those running their learning platforms should work closely to achieve a seamless integration, maintaining the educator in charge of defining the agent behavior. A relevant step forward would be to integrate the learning analytics from both the learning platform and the colMOOC platform. Institutions should look broadly at the potential of Conversational Agent mediated debates, as they are not only useful in large scale MOOCs. Finally, policy makers are recommended to promote the use of CA technology in formal education, especially in relation to the development of critical thinking and reasoning skills, as well as social competences, key to the preparation of citizens for the challenges of the 21st century. They are also encouraged to look at the ethical implications of using human sensitive data, such as conversation, to intervene in the learning process and analyze it.

References

Adamson, D., & Rosé, C.P. (2013). Academically productive talk: One size does not fit all. Artificial Intelligence in Education (AIED) 2013 Workshops Proceedings, 51-60.

Ananiadou, K., & Claro, M. (2009). 21st Century Skills and Competences for New Millennium Learners in OECD Countries, OECD Education Working Papers, No. 41. Paris: OECD Publishing.

Catalán-Aguirre, C., Gonzalez-Castro, N., Delgado-Kloos, C., Alario-Hoyos, C., & Muñoz-Merino, P.J. (2021). Conversational agent for supporting learners on a MOOC on programming with Java Computer Science and Information Systems (in press).

Demetriadis, S., Caballé, S., Papadopoulos, P.M., Gómez-Sánchez, E., Kolling, A., Tegos. S., Tsiatsos, T., Psathas, G., Michos, K., Weinberger, A., Bech. C.W., Karakostas, A., Tsibanis, C., Palaigeorgiou, G & Hodges, M. (2021). Conversational Agents in MOOCs: Reflections on first outcomes of the colMOOC project. In: Caballé, S., Demetriadis, S., Gómez-Sánchez, E., Papadopoulos, P., Weinberger, A. (Eds.). Intelligent Systems and Learning Data Analytics in Online Education. Amsterdam, Netherlands: Elsevier. ISBN: 978-0-12-823410-5. In press.

Directorate-General for Communications Networks, Content and Technology - European Commission (2019) Ethics guidelines for trustworthy AI. Available from https://op.europa.eu/s/pdSF.

Domínguez, C. (coord.) (2018). A European collection of the Critical Thinking skills and dispositions needed in different professional fields for the 21st century. Vila Real: UTAD. ISBN: 978-989-704-256-0

Elen, J., Jiang, L., Huyghe, S., Evers, M., Verburgh, A., & Palaigeorgiou, G. (2019). Promoting Critical Thinking in European Higher Education Institutions: towards an educational protocol. C. Dominguez & R. Payan-Carreira (Eds.). Vila Real: UTAD. ISBN: 978-989-704-375-8

Hung, D., Lee, S. S., & Lim, K. (2012). Sustaining research innovations in educational technology through communities of practice. Educational Technology, 52(4). 33-36.

Kukulska-Hulme, A., Bossu, C., Coughlan, T., Ferguson, R., FitzGerald, E., Gaved, M., Herodotou, C., Rienties, B., Sargent, J., Scanlon, E., Tang, J., Wang, Q., Whitelock, D., & Zhang, S. (2021). Innovating Pedagogy 2021: Open University Innovation Report 9. Milton Keynes: The Open University.

Michos, K., Asensio-Pérez, J. I., Dimitriadis, Y., García-Sastre, S., Villagrá-Sobrino, S., Ortega-Arranz, A., Gómez-Sánchez, E., & Topali, P. (2020). Design of conversational agents for CSCL: comparing two types of agent intervention strategies in a university classroom. In European Conference on Technology Enhanced Learning (pp. 215-229). Springer, Cham.

Prieto-Santos, L.P., Asensio-Pérez, J.I. Muñoz-Cristóbal, J.A., Dimitriadis, Y. Jorrin-Abellán, I.M. & Gómez-Sánchez, E. (2013). Enabling teachers to deploy CSCL designs across distributed learning environments. IEEE Transactions on Learning Technologies, 6(4):324–336.

Fielding, R.T. (2000). Architectural Styles and the Design of Network-based Software Architectures. PhD Thesis, University of California, Irvine, CA, USA.

Rosé, C. P., & Ferschke, O. (2016). Technology support for discussion based learning: From computer supported collaborative learning to the future of massive open online courses. International Journal of Artificial Intelligence in Education, 26(2), 660-678.

Tegos, S., Demetriadis, S., and Karakostas, A. (2015): Promoting academically productive talk with conversational agent interventions in collaborative learning settings. Computers & Education 87, 309-325.

Tegos, S., Demetriadis, S., & Karakostas, A (2015).: Promoting academically productive talk with conversational agent interventions in collaborative learning settings. Computers & Education 87, 309-325.