

Course design with artificial intelligence agents

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Abstract: This article explores the creation of a "Introduction to Data Science" course employing state-of-the-art AI technology, utilizing the GPT-4 model from OpenAI and the CrewAI platform. The project uses a multi-agent system to create excellent teaching materials with the assistance of specialized agents. Every agent has a distinct role to do, which may be anything from planning the course and creating the presentation materials to creating the practical activities and ensuring their excellence. This study explores the ways in which large-scale language models facilitate the process of material production and optimization, ensuring the coherence and relevance of educational materials. Highlighting the benefits of utilizing AI and inter-agent communication in education, the case study showcases how a 12-week course with weekly one-hour sessions may be constructed using this technology. The results indicate that the integration of these technologies can significantly increase the efficiency and adaptability of teaching materials, providing students with a more creative and high-performing learning environment.

Keywords: CrewAI, AI agents, Educational Course Development, Inter-agent communication

1 Introduction

In the context of accelerated technological evolution, the integration of artificial intelligence (AI) in education represents a promising direction for improving learning processes. The application of sophisticated large language models (LLMs) and multi-agent systems presents numerous options for the creation of creative and useful teaching resources. [1] Through an extensive case study, the current project explores these technologies with the goal of creating a "Introduction to Data Science" course that makes use of the CrewAI platform and state-of-the-art AI models like OpenAI's GPT-4.

Large language models such as GPT-4 are artificial intelligence systems that have been trained on copious volumes of textual data to comprehend and produce natural language. From creating text and responding to enquiries to creating intricate and personalized content, these models are competent at a wide range of jobs. [2] In this

project, LLMs are used to support agencies in creating educational materials, including formulating course titles, developing presentation content and generating practical exercises. The ability of these models to produce coherent and relevant texts plays a crucial role in ensuring the quality and coherence of course materials [2].

Ensuring the coherence and relevance of instructional materials and exploring the role that LLMs play in generating and upgrading them are the primary objectives of the study. Examining the integration possibilities of these technologies to create a well-structured and productive learning program. Using the CrewAI platform to coordinate specialised agents that contribute to the creation of educational materials, including lesson planning, developing visual content, and creating practical exercises.

The case study presented in this paper focuses on using the CrewAI platform and the GPT-4 model to develop an “Introduction to Data Science” course. The CrewAI platform facilitates coordination between specialized agents, each with specific roles, such as Curriculum Designer, Topic Specialist, Schedule Coordinator and others. These agents work together to create a 12-week course schedule with weekly one-hour sessions.

The case study looks at how each agent contributes to different aspects of the course, including developing the overall structure, creating content for presentations, organizing practical exercises and ensuring quality. It evaluates how agents interact with one another as well as how successful teamwork affects project outcomes. AI technologies have a good effect on education since they make it possible to create customized and excellent educational content. This is demonstrated by the usage of LLMs in this context. [3]

This paper emphasizes the importance of integrating advanced technologies in education and highlights how multi-agent systems and large language models can transform the development of educational materials, providing an innovative and effective learning experience.

The remainder of the paper is organized into several key sections. Section 2 provides a detailed overview of the course design, the use of artificial intelligence, focusing on the contributions of specialized providers in the structuring, content creation and quality assurance of the course. In Section 3, the system efficiency as a whole is evaluated, together with the development module and an assessment of the agents' cooperative efforts to provide instructional materials. Section 4 wraps off by talking about the possible ramifications of utilizing AI in the creation of instructional materials and summarizing the key findings.

2 Course design with AI

The use of artificial intelligence (AI) in the design of educational courses marks a significant shift from traditional methods to more efficient, adaptive and scalable approaches. [4] In this project, AI technologies, especially large language models (LLMs) such as OpenAI's GPT-4 and a multi-agent system operated on the CrewAI platform, are used to automate and simplify the development of an introductory course

in "Data Science ". This section explores how AI agents, each with specialized roles, contribute to the structuring, content creation, and quality assurance of the course.

2.1 The objective

This project aims to provide a thorough and organized course named "Introduction to Data Science" utilizing a multi-agent system. Each agent has an own area of expertise when it comes to producing instructional materials. Together, they provide a variety of resources, including course syllabus, presentation content, supplemental materials, and hands-on exercises.

The main aim is for the final course materials to be coherent, progressive and suitable for a 12-week program with weekly 1-hour sessions. In this process, the agents have well-defined roles: from defining the general structure and titles of the courses, to developing the main themes for each session and organizing a logical program to cover all the proposed themes. Presentation content is developed to be engaging and informative, supplemented by relevant additional resources such as articles, books or other industry references. In addition, practical exercises are created to support theoretical learning through practical applications.

In order to divide work effectively and maintain consistency and overall material quality, the system makes use of collaborative AI agents, where each agent works on a particular area of the course. Creating a top-notch educational program that offers a thorough introduction to data science in an interesting and productive way for learners is the ultimate goal.

2.2 The platform

Using the CrewAI platform, the developed code aims to provide a comprehensive educational course by coordinating and integrating the activity of multiple specialized agents. In order to ensure efficiency and accuracy in the creation of instructional materials, we employed OpenAI to oversee and automate activities allocated to agents.

The OpenAI API key is set up in the first section of the code, granting access to the required CrewAI platform resources. This key is necessary to guarantee that all of your interactions with the platform are valid and operating as intended. The functions required for file management and result organization are defined after the API key has been configured. Advanced artificial intelligence models, like GPT-4 from OpenAI, are capable of producing text, responding to queries, and carrying out other NLP functions. In order to carry out certain tasks, like coming up with course titles, setting assignments, or producing content for presentations, programs can interact with these models thanks to the API key. [5]

For the purpose of integrating and coordinating the efforts of artificial agents, CrewAI uses OpenAI technology. The API key provides access to the resources required to finish agent tasks, guaranteeing reliable outputs that meet predetermined standards. The agents produce outcomes based on OpenAI models that are combined and arranged in a logical manner. By giving constant access to AI models and the

functionality required to process and store results, the API key makes this integration easier. [6]

Agents are carefully defined in code, each with a backstory, a description, and a specific goal. These individual characteristics help configure agents to perform their roles in a well-defined and efficient manner. Each agent has a backstory that defines their relevant expertise and experience. Given the agent's unique experience and expertise, this context influences how the agent approaches tasks and decides what to do. A thorough explanation of their responsibilities within the project is also given to agents. It explains in full each agent's roles and responsibilities, giving readers a clear picture of how they fit into the creation of instructional materials. The primary aim of agents in the project is to achieve a specified target. By directing the agent's work, this objective guarantees that every assignment is completed in accordance with set standards and expectations.

Tasks are managed by Task objects. Each task represents a set of specific instructions assigned to an agent to contribute to the ultimate goal of the project, which is the development of a complete educational course. Each Task is defined by several key components: description provides details about the task to be performed. Agents might be asked to come up with course titles, homework assignments, presentation material, exercises, and practical activities, for instance. Agents can better understand their responsibilities and how to achieve their objectives by having job descriptions that are clear and explicit. Expected output defines the desired result of the task. It is a clear specification of what the agent is expected to deliver, whether it is a list of titles, a detailed description of topics, content for slides or practical exercises. Determining the desired result in detail guarantees that the deliverables meet the specified requirements and aids in evaluating the task's success. Every task has a designated agent who is in charge of seeing to it through to completion. Since agents have diverse functions and areas of knowledge, jobs are assigned according to the level of skill needed.

After the tasks are defined, it is necessary to form the work team, called Crew. This step involves the following aspects: The team (Crew) consists of a group of agents who are selected according to their skills and the tasks they have to perform. In the code presented, agents such as Curriculum Designer, Topic Specialist, Schedule Coordinator, and others are included in the team. Each agent has a specific role that contributes to the achievement of the overall objective of the project. The team is responsible for coordinating and completing assigned tasks. Each agent works on its specific tasks and the results are integrated to form the final product. Within CrewAI, agents automatically collaborate to ensure efficient project delivery.

The Crew Kickoff, the official project launch, comes when the crew is established and tasks are delegated. To begin task execution and agent activity coordination, this stage is necessary. All tasks are assigned to the agents when invoking the kickoff() procedure, at which point they begin carrying out the instructions they have been given. Through the use of this technique, agents can start working together to create materials and do tasks. Once the project has begun, CrewAI arranges agent contacts and keeps track of each task's advancement.

2.3 The agents

I'll go over each of the seven defined agents in depth in this section, including their functions and responsibilities.

The first agent is the Curriculum Designer, who is in charge of coming up with the course's general framework. In particular, it produces a list of short, straightforward lesson titles that highlight the most important details of each subject for every course lesson. The agent is skilled in planning a logical progression of subjects and organizing and structuring educational programs. Curriculum Designer provides titles that show a clear progression from foundational data science topics to more complex ideas, all while maintaining a consistent level of difficulty.

The next agent is the Topic Specialist, whose job it is to specify the particular subjects that each course session will cover in order to broaden the titles that Curriculum Designer offers. Lessons need to be sufficiently defined to fit into a one-hour class. Because of their extensive knowledge in data science, this agent can simplify difficult subjects into issues that are understandable and pertinent to newcomers.

The Schedule Coordinator agent's job is to arrange the courses into a 12-week program with one-hour sessions per week. The agent also makes sure that the subjects are organised logically. The prepared schedule needs to make sense such that each lesson builds on the information from the one before it. To prevent overburdening the students, this agent arranges the lessons in the best possible order and disperses the content evenly.

In addition to providing instructional materials for each session, such as concepts, examples, graphics, and definitions, the Slide Content Developer is in charge of creating the content for the slides that will be utilised in the class. To create a balance between visually appealing and instructive material, the agent suggests combining text, photographs, and visual examples. The slides are made to be easy to navigate, and the content should be understandable and clear enough for students.

The Curator of Supplementary Content is in charge of gathering and arranging supplemental materials to help students expand their knowledge. These materials include websites, books, articles, and other insightful sources related to the course subject. The agent makes sure that these resources support the content covered in class and offer possibilities for independent study by using his research and selection abilities to find the most relevant and current data science resources.

Each course session's exercises and practical tasks are designed by the Exercise and Lab Coordinator to help students apply academic concepts in a real-world context. To encourage practical thinking, the agent creates exercises with varying degrees of difficulty. These provide students with opportunity to engage with actual data and are in line with the course subjects.

Assuring that the contents are accurate, logical, and educationally beneficial is the primary responsibility of the Quality Assurance Specialist, the final agent, who also reviews and edits the materials created by the other agents. He examines every bit of content, verifies the information's authenticity, and examines the course's cohesion throughout its many sections. Also, it makes sure that the information is presented in a way that makes it easy for students to understand.

2.4 The interaction between the agents

As part of the project, the agents work closely together to create the materials for the "Introduction to Data Science" course. It is mentioned that they work alone, however there is no command in the code that precisely requires this. Every agent has a specific role, and effective coordination and the calibre of the materials produced depend on how well they interact with one another. They communicate by asking questions of one another, which is typically displayed in the output as "Asking a coworker a question" before the question itself is displayed. They claim that they can now finally complete the task with excellent results after gathering the necessary data.

```
Action: Ask question to coworker
Action Input: {"question": "Can you provide a list of comprehensive and concise course titles for the
'Introduction to Data Science' program?", "context": "We need a list of course titles that capture the
essence of each topic within the 'Introduction to Data Science' program. Each title should be concise
and informative.", "coworker": "Topic Specialist"}

> Entering new CrewAgentExecutor chain...
Thought: I now can give a great answer
Final Answer: my best complete final answer to the task.
```

Figure 1 - Example of an interaction between agents

I decided to depict their interaction as a graph (figure 2), with each node standing in for an agent and the lines connecting the nodes signifying their direct cooperation with one another.

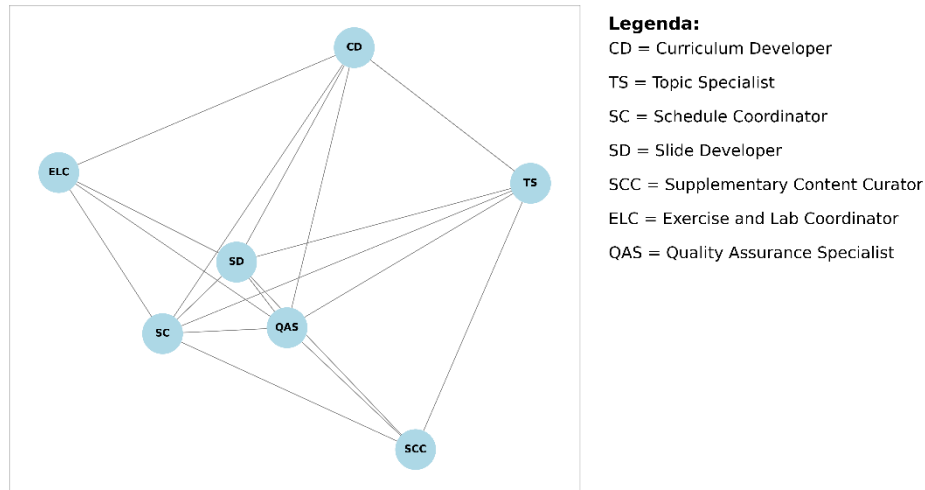


Figure 2 - Graph depicting the interaction between agents

Course title creation falls within the purview of Curriculum Designer (CD). It communicates with the Topic Specialist directly in order to deliver the list of titles that will serve as the foundation for the course themes.

Curriculum Designer's titles are expanded into in-depth topics by Topic Specialists (TS). The primary content for the presentations is provided by the Topic Specialist, so cooperation between the Topic Specialist and the Slide Developer (SD) is essential. Furthermore, in addition to working with the Exercise and Lab Coordinator (ELC) to make sure that the practical exercises match the topics addressed, the Topic Specialist also engages with the Supplementary Content Curator (SCC) to find supplementary materials that enhance the major themes.

The Schedule Coordinator (SC) is in charge of setting up the course schedule. They collaborate closely with the Topic Specialist and Curriculum Designer to guarantee that the classes are arranged logically and progressive. Along with integrating practical activities into the plan, the plan Coordinator communicates with the Exercise and Lab Coordinator (ELC) and the Quality Assurance Specialist (QAS) to verify and modify the program as needed.

Each session's visuals are largely produced by the Slide Content Developer. He collaborates mostly with the Topic Specialist, who supplies his main content, but he also works with the Supplementary Content Curator to provide further details to the presentations. To guarantee that the slides are accurate and consistent, Slide Developer works in tandem with Quality Assurance Specialist (QAS). In order to separate the slides effectively by week, it also communicates with the Schedule Coordinator.

The Curator of Supplementary Content (SCC) gathers and arranges extra materials to enhance the curriculum. Engages with the Exercise and Lab Coordinator to locate pertinent materials for hands-on learning, and with QAS to confirm the accuracy and applicability of suggested materials.

Creating hands-on exercises and activities is the responsibility of the Exercise and Lab Coordinator (ELC). Create exercises that are pertinent to the subjects covered in close collaboration with the Topic Specialist. Then, work with the plan Coordinator to incorporate these exercises into the weekly plan. Additionally, the ELC and QAS work together to guarantee that practical tasks are effective and transparent.

All materials created by outside agents are verified by the Quality Assurance Specialist (QAS). To guarantee that the materials are logical, well-structured, and of the highest caliber, QAS collaborates with each individual agent, including curriculum designers, slide developers, and exercise coordinators. In order to improve the material, QAS makes changes and offers input during this process.

3 Results

Considering the complexity of the tasks and the amount of work required to ensure delivery on time, the results were better than anticipated. The team has shown itself to be exceptionally skilled at providing comprehensive explanations without yielding unneeded or erroneous outcomes. Agents shown initiative and cooperated to trade remarks or further information as needed, even though the initial code included no mention of collaboration. Some agents even got to communicate directly with each colleague, thus optimizing the work process and contributing to the quality of the final product. The console displayed the task of the active agent for each output that the agents produced. In cases when additional team members were required, the process commenced with a "thought" in which the necessary work was outlined, and the agent ultimately provided the outcome. Delivering anticipated results and cooperating amicably, every agent fulfilled their designated roles with success.

```
> Entering new CrewAgentExecutor chain...  
Thought: To come up with a comprehensive list of course titles for the "Introduction to Data Science" program, I should seek input from the Topic Specialist who has in-depth knowledge of the subject matter.
```

Figure 3 - An agent having a thought

It was the Slide Content Developer's responsibility to create slides with templates for teacher presentations. He successfully managed the agents' work by assigning them specific duties and ensuring that the finished product was flawless. "Delegate work to co-worker" was a newly introduced activity that entailed asking other coworkers for assistance in accomplishing specific tasks and supplying them with pertinent resources. It's amazing how agents recognize their own limitations and ask for help in order to provide the finest version.


```

To begin developing the content for the slides, I need to gather more detailed information on some of the topics to ensure completeness and accuracy. I'll need to coordinate with the Topic Specialist, Curriculum Designer, and other relevant coworkers.

First, I'll delegate tasks to ensure each topic is thoroughly covered:

1. **Delegate to Topic Specialist**: Ensure detailed content for each session.
2. **Delegate to Curriculum Designer**: Validate the curriculum structure and ensure it aligns with learning objectives.
3. **Delegate to Supplementary Content Curator**: Gather visuals, examples, and additional reading materials.
4. **Delegate to Exercise and Lab Coordinator**: Develop practical exercises and labs for hands-on learning.
5. **Delegate to Quality Assurance Specialist**: Review the content for accuracy and comprehensiveness.

I'll start by delegating tasks to the Topic Specialist for the detailed content.

Action: Delegate work to coworker

```

Figure 4 - SCD delegating tasks to other agents

Although not included in the initial specifications, the team also proposed a project theme for the completion of the course, detailing both the requirements and how to deliver it. The order of topics in each course follows a logical structure, from introductory concepts to more advanced concepts, with each course supported by supplementary materials and laboratory exercises.

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Final Answer:

1. Introduction to Data Science and Its Applications
2. Fundamentals of Data Analysis
3. Data Collection and Cleaning
4. Exploratory Data Analysis (EDA)
5. Introduction to Statistical Inference
6. Introduction to Machine Learning
7. Supervised Learning Techniques
8. Unsupervised Learning Techniques
9. Data Visualization Techniques
10. Introduction to Big Data and Cloud Computing
11. Ethics in Data Science
12. Capstone Project: Application of Data Science Concepts

```

Figure 5 - Example of an output, project included

The Supplementary Content Curator has managed to gather relevant supplementary material for students, including books, websites and articles, carefully selected for each week and topic. The Exercise and Lab Coordinator has developed a series of exercises and lab activities for each class session.

All of the content that the other agents had submitted was examined by the top agent, the Quality Assurance Specialist, who gave objective, helpful criticism. Although I had anticipated excellent responses, it was able to point out areas that needed development and offer helpful advice.

```

**Overall Recommendations:**
1. **Update Scenarios in Week 2:** Ensure all scenarios are current and relevant to today's context.
2. **Provide Additional Examples for Complex Exercises:** Offer more examples or guidance, especially for advanced exercises.
3. **Continue Emphasizing Hands-On Experience:** Maintain the focus on practical applications and hands-on learning, as this is highly effective.

By implementing these recommendations, we can ensure that the exercises and lab activities not only align with the learning objectives but also provide a comprehensive, clear, and meaningful learning experience for the students.

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Figure 6 - QAS giving feedback

A closer look at the data, however, indicates certain issues and limitations with the approach. While agents have exhibited excellent collaboration, there are a few nuances that AI agents may overlook while working without human supervision. Without a good awareness of the context, it can be difficult to develop consistency across different lessons and how they address the specific needs of a given audience. Although agents have demonstrated proficiency in activities such as material creation and resource organization, tailoring them to the learning styles of various student groups remains an ongoing project. This means that agents are limited in their ability to incorporate advanced instructional insights that are best offered by human specialists.

On the other hand, another important result is the optimization of work through collaboration between agents. Although the initial code did not include detailed specifications for direct collaboration between them, the agents were able to interact and share information autonomously, resulting in increased efficiency and a more integrated final product. This emergent behavior suggests a great potential for agents to learn and adapt work processes, something that could be harnessed in future projects through more sophisticated programming of interactions between agents.

In terms of educational impact, these findings clearly demonstrate that the application of artificial intelligence can improve the efficiency with which educational materials are developed. Agents can considerably reduce the time required to produce a whole course while ensuring a consistent structure of the material. However, it should be highlighted that the strategy works best in introductory courses with a clear framework and learning objectives. In more advanced courses, particularly those that require a multidisciplinary approach, the interactions between agents and the complexities of the materials may entail a more complete examination and refinement of the functionalities.

Another important aspect of the results is the potential of these solutions to improve access to education. AI agent-based solutions such as CrewAI can enable the rapid development of customized courses for a variety of audiences, including students in disadvantaged areas or in online learning environments. This ability to scale and adapt can help to broaden education by making quality educational materials available to a larger number of students. However, this reform is dependent on having access to technology and ensuring that the contents produced are pedagogically suitable to each given environment.

From these results, we can assume that AI-based solutions are promising for education, but require adjustments to be fully effective in all scenarios. In the future, it could be beneficial to integrate mechanisms that allow real-time human feedback to correct or improve agent-created materials, thus ensuring a level of adaptability to meet the specific needs of students.

4 Conclusion

The paper demonstrates the positive impact of integrating advanced artificial intelligence technologies, such as GPT-4 and multi-agent systems, in the process of developing educational materials. The results obtained emphasize the ability of agents to collaborate effectively to create a coherent, adaptable and high-quality educational program. The suggested method was not only effective and scalable, but it also enabled instruction materials to be customized, increasing the learning process' inventiveness. The influence of such technology is enormous, providing new opportunities for curriculum personalization and educational improvement.

Such techniques might eventually be extended to more complicated courses that incorporate computerized tests or customized student feedback. There is also promising potential in the application of these technologies in other educational fields, such as vocational training or continuing education, where adaptability and constant updating of materials are essential. The development of interactive, fully automated educational platforms that provide real-time personalized content could represent a future research direction fueled by the solution presented in this paper.

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