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Accuracy and detection of student use of ChatGPT in business analytics courses

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Abstract

The recent emergence of artificial intelligence models such as ChatGPT has presented challenges and opportunities to educators. The goal of this study was to develop an understanding of the capabilities of ChatGPT in aiding students in business analytics courses, the implications on academic integrity and ethics on student utilization of ChatGPT and ultimately the potential impact on the field of business analytics. Using examples from introductory courses in Python programming for business analytics and optimization using linear programming, we found that ChatGPT provides accurate solutions to introductory quizzes and assignments and that its use may be possible for instructors to detect. This study provides a foundation for future research on the significant impact that artificial intelligence will pose to higher education in years to come.

Keywords: business analytics, generative AI, ChatGPT

Introduction

Artificial Intelligence (AI) models such as ChatGPT have gained widespread attention for their impact on higher education. While AI provides substantial potential benefits across various facets of work and life, it has become a disruptive force in higher education due to its ability to generate text for essays, answer test questions, and provide detailed instructions for assignments across various disciplines. The use of AI among students presents challenges to instructors who may feel that it undermines learning goals that include the development of foundational skills and independent thought that can be circumvented by simply posing questions to an AI. In response, instructors, administrators, and staff at institutions of higher education have been required to identify the utilization of AI by students and quickly devise strategies of preventing and monitoring its use, while also conceiving of new pedagogy that makes use of AI while still achieving the learning goals of their students.

In the field of business analytics, AI is particularly useful to students because the systems are able generate code in several programming languages and provide solutions or step by step instructions to complete tasks that might otherwise require more in-depth critical thinking, particularly foundational critical thinking skills being taught at the university level. In this study, we will examine existing literature surrounding AI, focusing in particular on ChatGPT and its impact on higher education and business analytics education. We will then illustrate how ChatGPT provides solutions to specific assessments in two common areas of business analytics courses, Python programming and optimization. In addition to assessing the accuracy of the solutions that ChatGPT provides, we will also comment on ways that student use of ChatGPT might be identified by instructors and how assignments and exams might be adjusted to limit its effect. We also

suggest ways that future business analytics pedagogy could make use of AI to allow students to learn about its potential benefits, limitations and ethical considerations. Lastly, we offer conclusions and potential areas for future research.

Background

Artificial intelligence (AI), generative AI in particular, has witnessed remarkable advancements over the last few years and while it holds great potential for transforming business analytics education. There are also some significant risks and challenges that need to be overcome. Here we discuss some of the research on the risk for violations of academic integrity and ethical concerns around the utilization of artificial intelligence in higher education and business analytics

ChatGPT and academic dishonesty in higher education and business analytics

As ChatGPT emerged as a resource for students, there was an immediate concern about academic dishonesty. Cotton et al. (2023) discussed the challenges of GPT-3 in higher education. The authors believe that the ability to generate essays potentially "undermines the very purpose of higher education, which is to challenge and educate students, and could ultimately lead to a devaluation of degrees." With the increasing role of online education, particularly in the aftermath of the COVID epidemic, there has been an increased awareness of threats of academic dishonesty. Gordon (2023) summarized how educators are reacting to ChatGPT, noting that some universities (and even countries) have banned its use.

The study reviews perspectives on academic dishonesty, student privacy and anxiety, and ways that educators can evolve their teaching methods to ensure that students build critical thinking skills. Conversely, Biswas (2023) discussed the positive aspects of ChatGPT in education noting its potential to enhance tutoring, research, paper reviews, class scheduling, personalized learning, virtual office hours, and student engagement.

Noorbehbahani et al. (2022) reviewed 58 publications to provide insights into cheating motivations, cheating types, cheating detection, and cheating prevention in the online setting. In their comprehensive review, AI is only cited in one publication, demonstrating how recently the impact of AI has emerged. In the field of business analytics, AI models raise particular concern due to their capabilities of generating code in various programming languages and providing detailed instructions for tasks that might otherwise require a greater degree of critical thinking and problem solving.

Historically, academic dishonesty has been a challenge in disciplines that require coding or other specific digital solutions. Roberts (2002) reviewed incidents of dishonesty at Stanford University over a decade, and found that 37% of all incidents were attributed to computer science courses, while their students represented less than 7% of the student population at the university. Thus, we expect that preventing and detecting academic dishonesty in business analytics to pose a similar challenge in years to come.

If instructors wish to restrict the use of an AI, there are several options, including establishing policies, using proctoring software, creating assignments that require unique or personalized responses, and actually making use of an AI. It is important to have clear communication with students regarding the use of AI, ideally starting with the first day of class but with stated policies and verbal reminders throughout the course. While it may seem obvious to prohibit the use of ChatGPT in a course syllabus, there are multiple AI tools in various stages of development that are likely to become increasingly common resources used in various aspects of work. For example, in the case of programming, new versions of integrated development

environments (IDE) will soon include AI that allow developers to combine manual and automated coding (Das, 2023). Thus, it may be important to be specific about the use of AI in each assignment or quiz and devise a method of prevention or evaluation. During an exam, proctoring software can guard against cheating is by monitoring students' computer screens, keystrokes, and web browsing activity during online exams. This can help detect if a student is accessing unauthorized materials or communicating with others during the exam.

Software can also use algorithms to analyze students' behavior during the exam. For example, the software can analyze how long a student takes to answer each question, their typing speed, and their response time to determine if they are using external resources to answer questions. Ultimately, if we are operating in a world where AI tools are used to supplement work, it makes sense to alter our pedagogy accommodate their use. This may require instructors to design more unique and personalized problems or require presentations where students must demonstrate their understanding of their solutions. Lastly, while AI can provide accurate solutions to some problems, it may do so in ways that can be detected if instructors are familiar with their use and the output they would provide to prompts that students are likely to input.

ChatGPT and ethical concerns in higher education and business analytics

Integration of AI language models raises important ethical considerations. Biases, misinformation, and data privacy concerns must be carefully addressed to ensure responsible and beneficial use of AI. Concerns with bias and discrimination in AI are of utmost importance as they highlight the potential for AI systems to perpetuate societal biases, leading to unfair treatment and marginalization of certain groups.

In the paper by Cavazos et al. (2020), they highlight the issue in the context of facial recognition systems. They conduct an extensive evaluation of multiple algorithms across different racial groups, revealing significant disparities in accuracy. There is clearly a need for ongoing research and development to address these concerns as it is crucial to ensure equitable and ethical deployment of AI technologies and to promote inclusive and unbiased decision-making processes.

In addition to the concerns with biases in models, the accuracy of AI, ChatGPT in particular is of concern. While it is still being explored and evaluated (Surameery et al. 2023, Tlili et al., 2023), it’s clear that it’s far from perfect and there are ethical concerns about inaccurate AI content generation leading to the spread of misinformation. In their paper, Liao et al. (2021) examine the challenges posed by misinformation and manipulation in the context of AI language models. In the study by Zhou et al. (2023), they analyze the characteristics of AI-generated fake news and evaluate the effectiveness of algorithmic and human-based solutions in detecting and mitigating the spread of misinformation. Both of these studies highlight the need to further study this area to better understand how to combat the challenges posed by AI-generated misinformation.

Finally, the use of AI may involve processing and analyzing sensitive data, raising concerns regarding privacy, consent, and data security. This is of particular concern as consumers may not readily perceive the potential risks to data protection and privacy posed by advanced AI technology, as it possesses the capability to extract sensitive personal information. In the study by Horwitz & Mulligan (2015), they explore the potential risks and vulnerabilities of AI-driven big data processing and highlights the need for robust privacy and security measures. They emphasize the importance of research advancements and the development of standards to address these concerns and protect individuals' privacy while promoting the responsible use of AI technologies.

Methodology

In order to evaluate the impact of student use of AI in business analytics coursework, we used ChatGPT to provide responses for selected assignments and quizzes for courses in introductory Python for Analytics and Optimization. For the Python course, we input four quiz questions from a textbook titled Introduction to Python Data Analytics. The quizzes included content of varying complexity including: variable definition, flow control, input-processing-output, and collections (list and dictionary variables). For each quiz, we provide commentary on the accuracy of ChatGPT in generating the code and also on the ways that an instructor might detect that ChatGPT was used.

In the optimization course, we created seven linear programming problems for evaluation purposes. Among these, five problems were assigned as homework, while two were included in the exam. Students had access to ChatGPT for assistance with the homework, but not during the exam, which was conducted in a classroom setting with computer-based exams, in-person proctoring, and screen recording software. ChatGPT generated answers for all seven problems, allowing for an assessment of their accuracy. Additionally, we performed an ANOVA analysis to compare the average scores of the homework and exams over the past six semesters in which the course was taught.

Results

Python for data analytics quizzes

Quiz 1

Quiz 1 had four questions. The first question required very simple code to compute the area of a circle given hard coded values for the variables used in the equation. The second question simply required a print statement that concatenated output from question 1. Questions 3 and 4 were multiple choice questions that asks students to identify the correct syntax for code that might be used in the prior questions. Not surprisingly ChatGPT was 100% accurate in its code for all four questions, including the multiple-choice questions. ChatGPT does follow a predictable format of including comments after each response. If students did not omit these comments, it would be a strong indicator that ChatGPT was used but otherwise, it be fairly difficult to detect because of the simplicity of the code. In general, instructors may wish to limit the use of multiple-choice questions because of the lack of unique responses that are detectable.

Quiz 2

Quiz 2 was a single question quiz that required students to collect input from user regarding height, weight, and gender and use if/else/elif statements to detect and print potential errors. The quiz required students to devise their own criteria for determining height and weight outliers, but provided a list of allowable entries for gender. The code provided by ChatGPT for this quiz was very accurate but also would require significant editing for a student to avoid detection of ChatGPT use. One aspect of ChatGPT is that it provides a standard set of code regardless of the level of expertise of the user. For example in this quiz, it uses .lower() method to convert inputs to lower case and .isdigit() method to identify non-numeric entries. These are methods that students would not yet have been taught at this stage of the course. The code uses a list of allowable inputs (if variable in [“x”, “y”, “z”]) while students would typically use a series of “or” entries. There are also numerous specific code styles, use of double vs single quotes, number of lines of code, comments after each part of the code, and the specific numeric parameters for identifying outliers.

Quiz 3

Quiz 3 was a single question quiz that required students to prompt users to input three employee names, hours worked, and hourly pay along with a tax rate, then output a formatted table showing the resulting employee pay and totals. In a similar fashion to quiz 2, the solution provided was accurate but also very unique given the requirements. While much of the code was fairly generic, with inputs for each variable and totals that are fairly simple, ChatGPT imported two libraries to facilitate the printed output. The output of a table was intended to be a general use of the term (code would generate headings and values for each employee in a tabular style) but ChatGPT took the instruction literally and imported libraries named "tabulate" and "termcolor" to make use of functions to format the output.

Quiz 4

Quiz 4 provided students with a hard-coded list variable for terminated employees, and a hard coded dictionary variable for active employees and their hourly pay. The quiz requires students to prompt the user to add, remove, or update employees and collect the required inputs and produce the required outputs based on their responses. The response by ChatGPT were once again accurate and fairly generic except that it included a very unusual addition – the code required was indented inside of a "while loop" that checked for invalid entries. Students would be very unlikely to interpret this requirement and would not yet have learned that functionality. If students were to omit the "while loop", the code indented provides a solution that is fairly generic and would be fairly difficult to detect assuming the students removed comments, adjusted spacing, variable names, etc…

In summary, ChatGPT was very accurate in providing solutions to quiz questions in the textbook but, except for the very simple introductory quiz, provided solutions would raise suspicion to an instructor, particularly if the instructor had used ChatGPT to pre-check the potential responses. While these are just four introductory quizzes in the course, additional quizzes with more complex content (within the framework of an introductory course) would provide similar implications with ChatGPT providing a high level of accuracy, but with solutions that would raise suspicion. For an advanced course or projects with more intricate requirements, ChatGPT would be unlikely to provide accurate solutions unless used iteratively and in conjunction with edits as needed.

Table 1: ChatGPT use for Python Quizzes

Quiz Topic	Accuracy of ChatGPT Solution	Likelihood that ChatGPT use would be detected
Quiz 1: hard coded variables, simple equation, printed output, multiple choice questions on correct syntax	Very accurate	Very unlikely to detect use unless pasted verbatim with comments included
Quiz 2: inputs from user, use if/elif/else criteria for printing outliers of entries	Very accurate	Very likely to detect use due to style of coding, use of lists, and specific values required
Quiz 3: inputs from user, computing totals, formatting printed output in tabular format	Very accurate	Very likely to detect use due to imported libraries that were not required for basic solution
Quiz 4: hard coded list and dictionary. Prompt user for action and display, edit or add to list or dictionary.	Very accurate	Somewhat likely to detect use due to use of While loop to maintain persistent connection not required in instructions.

Optimization: Introductory linear programming problems

In the optimization course, we created seven linear programming problems for evaluation purposes. Among these, five problems were assigned as homework, while two were included in the exam. The first three homework problems consisted of straightforward two-variable optimization problems designed to offer students their first opportunity to practice constructing linear formulas that represented a selection of optimization scenarios. The fourth problem presented a make-vs-buy scenario where they had to determine the appropriate mix of products to make in-house vs. buy from external suppliers in order to meet demand given a set of constraints. The fifth and final homework problem presented a blending optimization scenario where they had to determine the optimal mix of ingredients in an essential oil blend that met specific constraints. All student submissions for the homework were individually submitted and evaluated by the professor, which included written feedback not only on the correct identification of the decision variables, objective function, constraints, and solution, but also the appropriate utilization of mathematical notation. Historically, these assignments take longer to grade than assignments later in the semester due to the considerable amount of written corrections required. This is primarily because students are in the initial stages of learning the fundamentals of constructing linear models in written form.

Given the simple nature of the first four homework problems, ChatGPT easily generated the correct solution. But when the professor graded these assignments, two things stood out. First, the grading seemed to take significantly less time than in the past as there were not many corrections needing to be made. Second, in one of the problems, individual constraints were provided in "minutes" while the totals were provided in "hours". As this is the first time they encounter a problem with this type of mixed units in the constraint, there is usually a combination of the following three responses; they convert everything to minutes, they convert everything to hours, or they incorrectly write equations with part of the constraint written in minutes and the other part in hours. In the semester where they had access to ChatGPT, 96% of the students used minutes and 4%, only 1 student, had incorrectly set it up with mixed units. As a comparison to the prior semester, when given a similar problem, but the students did not have access to ChatGPT, 70% of the students used minutes, 13% of the students used hours, 17% set it up incorrectly with mixed units. The result generated from ChatGPT was set up in minutes.

The fifth and final homework problem presented a blending optimization scenario where they had to determine the optimal mix of ingredients in an essential oil blend that met specific constraints. In class, the concept was taught through a traditional method of weighted averaging. In this method, the numerator involves multiplying the numbers to be averaged by their respective weights and then summing them. The denominator consists of the sum of the values being averaged. (Formula 1). A correct, mathematically equivalent solution was generated by ChatGPT that multiplied the denominator by both sides (Formula 2). As with prior semesters, students were briefly introduced to Formula 2 as a mathematically equivalent solution that was written on the board as part of an example worked in class, but it was not in the printed course materials. On the homework submitted, 73% of the students used Formula 2.

Formula 1:

$$W = \frac{\sum_{i=1}^{n} w_i X_i}{\sum_{i=1}^{n} w_i}$$

Formula 2:

$$W * (\sum_{i=1}^{n} w_i) = \sum_{i=1}^{n} w_i X_i$$

W = weighted average
n = number of terms to be averaged
w_i = weights applied to the x values
X_i = data values to be averaged

On the two problems assigned for the exam, one was a simple two-variable linear optimization and the other problem was a blending optimization. Despite not having access to ChatGPT, students grasped the overall concept on the first problem and struggled only slightly with the mathematical notation. They did not perform well on the second one, blending optimization problem.

For the homework problem, the students were provided a constraint that stated they needed to produce 1,500 lbs of essential oil, thus $\sum_{i=1}^{n} w_i$ = 1,500. On the exam, they were not provided the exact unit to produce, thus needed to sum the decision variables as seen in the left-hand side of that equation. Given that it was an LP model, they needed to use Formula 2 to maintain linearity. Despite 73% of the students using Formula 2 on the homework, only 4% of the students accurately applied the same formula on the exam.

Given the high scores on the homework assignments and surprisingly low scores on the exam, an ANOVA analysis was conducted to compare the mean homework and exam scores from the most recent six semesters that this course has been taught; Spring 2023, Fall 2022, Spring 2022, Fall 2021, Spring 2021, and Fall 2020. While the problems are not exactly the same semester-to-semester, teaching materials are identical each semester, the same professor has been teaching all sections of this course, and the professor simply created new variations of these problems each semester.

For Spring 2023, the average homework score was a 92.57%, which was higher than the previous five semesters and statistically significantly different from all but the Spring 2021 semester (Tables 2, 4, & 6). For the exam, the Spring 2023 average test score was 76.36%, which was lower than the five previous semesters and again statistically significantly different from all but the Spring 2021 semester (Table 3, 5, &7).

Table 2: ANOVA Homework scores

Source	Sum of Squares	DF	Mean Square	F	Sig.
Between Groups	0.2945	5	0.0589	4.1061	0.0014
Within Groups	2.7538	192	0.0143		
Total	3.0482	197			

Table 3: ANOVA Exam scores

Source	Sum of Squares	DF	Mean Square	F	Sig.
Between Groups	0.4685	5	0.0937	6.8744	<.0001
Within Groups	2.6170	192	0.0136		
Total	3.0855	197			

Table 4 Homework Scores - Tukey post-hoc multiple comparisons

α = 0.050		LSMean[j]					
	Mean[i]-Mean[j]						
	Std Err Dif						
	Lower CL Dif	Fall	Fall	Fall	Spring	Spring	Spring
	Upper CL Dif	2020	2021	2022	2021	2022	2023
LSMean[i]	Fall 2020	0	0.008	-0.010	-0.047	-0.006	-0.109
		0	0.027	0.026	0.030	0.030	0.029
		0	-0.068	-0.084	-0.133	-0.093	-0.191
		0	0.085	0.065	0.040	0.080	-0.027
	Fall 2021	-0.008	0	-0.018	-0.055	-0.015	-0.117
		0.027	0	0.028	0.032	0.032	0.030
		-0.085	0	-0.098	-0.146	-0.106	-0.204
		0.068	0	0.062	0.036	0.076	-0.031
	Fall 2022	0.010	0.018	0	-0.037	0.003	-0.099
		0.026	0.028	0	0.031	0.031	0.030
		-0.065	-0.062	0	-0.126	-0.086	-0.185
		0.084	0.098	0	0.053	0.093	-0.014
	Spring 2021	0.047	0.055	0.037	0	0.040	-0.063
		0.030	0.032	0.031	0	0.035	0.033
		-0.040	-0.036	-0.053	0	-0.059	-0.158
		0.133	0.146	0.126	0	0.140	0.033
	Spring 2022	0.006	0.015	-0.003	-0.040	0	-0.103
		0.030	0.032	0.031	0.035	0	0.033
		-0.080	-0.076	-0.093	-0.140	0	-0.199
		0.093	0.106	0.086	0.059	0	-0.007
	Spring 2023	0.109	0.117	0.099	0.062	0.103	0
		0.029	0.030	0.030	0.033	0.033	0
		0.027	0.031	0.014	-0.034	0.007	0
		0.191	0.204	0.185	0.158	0.199	0

Tables 5: Exam Score = Tukey post-hoc multiple comparisons table

α = 0.050		LSMean[j]					
	Mean[i]-Mean[j]						
	Std Err Dif						
	Lower CL Dif	Fall	Fall	Fall	Spring	Spring	Spring
	Upper CL Dif	2020	2021	2022	2021	2022	2023
LSMean[i]	Fall 2020	0	-0.070	-0.044	0.012	-0.059	0.080
		0	0.026	0.025	0.029	0.029	0.028
		0	-0.144	-0.116	-0.073	-0.144	0.000
		0	0.005	0.029	0.096	0.025	0.160
	Fall 2021	0.070	0	0.026	0.081	0.010	0.150
		0.026	0	0.027	0.031	0.031	0.029
		-0.005	0	-0.052	-0.007	-0.078	0.065
		0.144	0	0.104	0.170	0.099	0.235
	Fall 2022	0.044	-0.026	0	0.055	-0.016	0.124
		0.025	0.027	0	0.030	0.030	0.029
		-0.029	-0.104	0	-0.032	-0.103	0.041
		0.116	0.052	0	0.142	0.072	0.207
	Spring 2021	-0.012	-0.081	-0.055	0	-0.071	0.069
		0.029	0.031	0.030	0	0.034	0.032
		-0.096	-0.170	-0.142	0	-0.168	-0.025
		0.073	0.007	0.032	0	0.026	0.162
	Spring 2022	0.059	-0.011	0.016	0.071	0	0.140
		0.029	0.031	0.030	0.034	0	0.032
		-0.025	-0.099	-0.072	-0.026	0	0.046
		0.144	0.078	0.103	0.168	0	0.233
	Spring 2023	-0.080	-0.150	-0.124	-0.069	-0.140	0
		0.028	0.029	0.029	0.032	0.032	0
		-0.161	-0.235	-0.207	-0.162	-0.233	0
		0.000	-0.065	-0.041	0.025	-0.046	0

Table 6: Homework scores – Least squares means

	Least Sq. Mean	Std. Error
Fall 2020	0.817	0.017
Fall 2021	0.808	0.020
Fall 2022	0.826	0.019
Spring 2021	0.863	0.024
Spring 2022	0.823	0.024
Spring 2023	0.926	0.023

Table 7: Exam scores – Least squares means

	Least Sq. Mean	Std. Error
Fall 2020	0.844	0.017
Fall 2021	0.914	0.019
Fall 2022	0.887	0.019
Spring 2021	0.832	0.024
Spring 2022	0.903	0.024
Spring 2023	0.764	0.022

While it would be impossible to prove if a student was using an AI tool such as ChatGPT to assist them on their homework assignments, the submission of such high-quality homework assignments so early in the semester and the unique aspects of their submissions raised some red flags. ChatGPT had been openly discussed in class and students were instructed not to use it for their homework, but 100% of them were aware of its existence and capabilities. Given the results of the ANOVA analysis, it seems highly probable that students sought some assistance from ChatGPT on their homework assignments and encountered difficulties applying the same concepts on their exam without the assistance of ChatGPT.

Discussion and Conclusion

In conclusion, the use of artificial intelligence (AI) models like ChatGPT in higher education, particularly in the field of business analytics, presents both opportunities and challenges. AI has the potential to greatly enhance students' learning experiences by providing code generation and step-by-step instructions for complex tasks. However, it also raises concerns about academic dishonesty, undermines the development of foundational skills, and poses ethical considerations.

Our study focused on ChatGPT and its impact on higher education, specifically in the context of business analytics education. Through our analysis of existing literature and the evaluation of ChatGPT's solutions for Python programming and optimization problems, we have gained valuable insights into the accuracy of the generated content and the potential for detecting its use by students.

The results of our study indicate that ChatGPT can provide accurate solutions for certain types of assessments, such as simple Python quizzes and introductory linear programming problems. The research also illustrates some ways that an instructor can identify when students are using AI tools to assist in their learning, despite being instructed not to use it. Using this information moving forward, there is a need for instructors in higher education to openly discuss and engage students in conversations about the appropriate use of AI in their coursework, devise strategies to prevent and monitor the use of AI models like ChatGPT

that violate course policies, but also explore ways to effectively incorporate AI into our pedagogical practices. Moreover, it is essential to address the ethical concerns surrounding AI use in higher education. The potential for academic dishonesty, the perpetuation of biases and discrimination, the spread of misinformation, and the risks to data privacy and security necessitate careful consideration.

The broad accessibility of powerful AI tools, like ChatGPT, in recent times has brought about significant changes in the academic community, offering a vast array of research topics to explore. Some suggestions for future research should focus on developing methods to detect AI-generated content, refining assessment approaches, and exploring ways to leverage AI as a learning tool while still promoting the development of critical thinking, independent thought, and foundational skills among students. Additionally, ongoing research and the development of standards are crucial to ensure responsible and beneficial deployment of AI technologies in the academic setting. Future research should also focus on the emerging ways to integrate AI into the curriculum. Case studies and pedagogical research can focus on ways that education can be enhanced rather than threatened by the emergence of AI and the best practices in using AI throughout a program while still teaching student foundational skills in a subject.

In conclusion, AI models like ChatGPT have the potential to revolutionize higher education, but their use must be carefully managed and monitored to ensure academic integrity, ethical considerations, and the achievement of learning goals. By understanding the opportunities and challenges presented by AI in education, we can strive to create a balanced and effective approach that leverages AI's potential while upholding the core principles of education.

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