A Curriculum for the Future

Emphasising Threshold Concepts & Practical Skills

Advisory Document

Embracing AI in education

Windesheim University of Applied Science

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hogeschool Windesheim

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Background

The following document is a component of a student-led project aimed at exploring potential avenues for integrating artificial intelligence (AI) into the curriculum of HBO-ICT at Windesheim. Over the course of this five-month project, the team scrutinized their existing academic program, pinpointing areas struggling to adapt to the rise of AI, and devised immediate and long-term solutions to address these challenges.

Recognizing that HBO-ICT isn't the sole program grappling with such changes, and in response to requests for more broadly applicable guidance, the team, in collaboration with the project supervisor, Teun Lucassen, has chosen to make this advice publicly available.

This advisory report comprises two main sections:

1. "Curriculum for the Future": This part outlines necessary curriculum modifications and the steps required to effectuate these changes.
2. "https://windesheim.tech/generative-ai /": This section provides an overview of noteworthy practices regarding AI uncovered during our project.

AI has played a pivotal role in supporting this project. It's worth noting that every word in this document has been produced by generative AI, under the diligent guidance and validation of the project team.

Enjoy your reading.

Introduction

As technology advances rapidly, it has become evident that traditional approaches to teaching programming may no longer be effective. In particular, we've observed that many students are turning to artificial intelligence (AI) to complete their programming exams, rather than learning the necessary skills and concepts themselves. This trend undermines academic integrity and the quality of education provided by our college. (Kirk, 2023)

It is time to rethink our curricula and redirect focus on key concepts that are pivotal in helping students develop expertise and practical applications. In order to ensure that our students are truly learning the skills they need to succeed in the field, we propose restructuring the current curriculum to emphasize the most important concepts, and separately, their practical applications. This approach aligns with Bloom's Taxonomy (Specifically, Revised Bloom's Taxonomy), which emphasises the development of multiple categories of thinking skills such as analysis, synthesis, and evaluation.

1. Problem

While AI can be a powerful tool for teaching and learning, it has also created a new problem that threatens the quality of education: students are using AI to complete their assessments (exams and essays), undermining their own learning and academic integrity.

It is easy to see why students are turning to AI. After all, AI can quickly and accurately complete complex tasks that would take a student hours to finish. It is similar to how we use calculators to solve complex math problems or spell checkers to correct our writing. In a sense, AI has become a "crutch" for students who are looking for an easier way to complete their assessments.

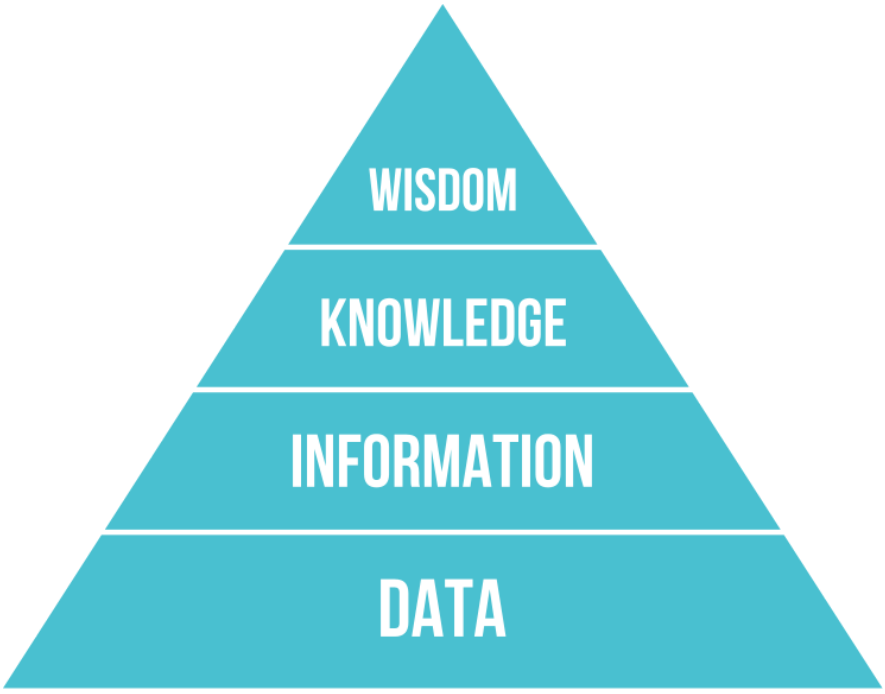
However, this reliance on AI is problematic for several reasons. First and foremost, it undermines the fundamental purpose of education: to learn and develop skills. When students use AI to complete their exams, they are not truly learning and incorporating the necessary concepts and skills to succeed in the field. This not only hinders their future job prospects but also devalues the degree that they are earning. As the Chinese philosopher Xunzi said, 'Tell me and I forget, teach me and I may remember, involve me and I learn.' AI is akin to 'tell me' and does not provide the same level of engagement and learning as active involvement in the learning process.

For example, when students rely on AI to complete their exams, they miss out on the opportunity to learn the critical thinking and problem-solving skills that are at the core of programming education. They may be able to produce a solution, but they don't truly understand how it works or why it is correct. This undermines the entire purpose of programming education, which is to teach students to think logically and creatively about solving complex problems.

1.1 Shortcuts Undermine Wisdom

According to the commonly known DIKW Pyramid (*Image 1: DIKW Pyramid*), also used by Stephen S. Hall in his book “Wisdom: From Philosophy to Neuroscience”, knowledge, information and data are the building blocks upon which deeper levels of comprehension and insight are built. This means that students cannot gain true insight into a subject if they rely solely on technology to complete their work (data).

Image 1: DIKW Pyramid



By contrast, students who have a deep understanding of the material and are able to apply their knowledge to solve problems (knowledge and information) are more likely to develop true insight and wisdom over time. Therefore, educators should prioritize teaching students the necessary knowledge and skills rather than simply accepting that they will use technology to complete their work.

Furthermore, the use of AI to complete exams undermines academic integrity because it bypasses the learning process that is necessary for students to truly understand the material. This is not only detrimental to the student's education, but it also undermines the value of the credential that they earn through the educational process.

In summary, by prioritizing knowledge and information over shortcuts only with data, educators can help students develop wisdom.

2. Solution

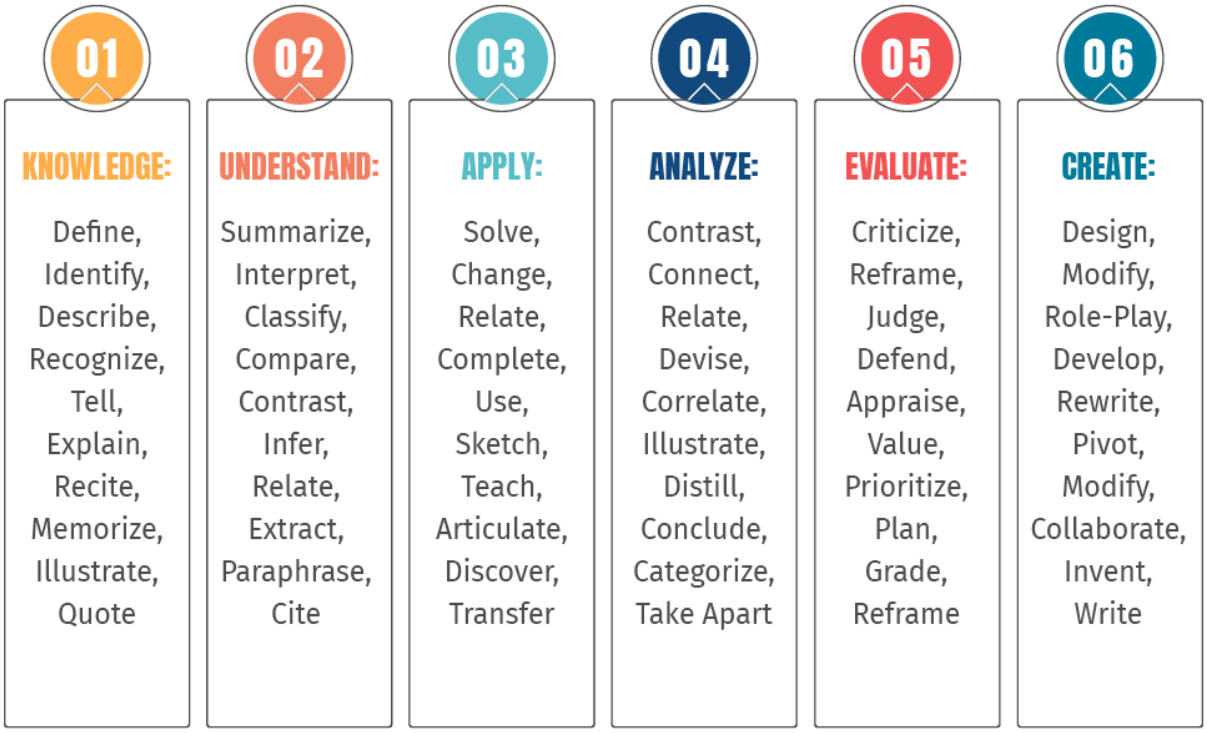
2.1 Threshold Concepts

Emphasizing so-called threshold concepts in a study course can help to address the issue of students not having to learn because AI can make their exams for them by shifting the focus from rote memorization of facts and information to a deeper understanding of fundamental concepts in the subject area. By focusing on threshold concepts, instructors can encourage students to engage with the material in a more meaningful way, which can foster a deeper and more lasting understanding of the subject.

Assessing student understanding of the identified threshold concepts is crucial to the success of the course design. Instructors can develop assessments that measure students' mastery of the fundamental concepts and determine if students have developed a deep understanding of the subject area. Assessments should measure students' understanding of threshold concepts, not just their ability to remember, and should align with learning outcomes. Instructors can also provide feedback to students to help them identify areas where they need to improve their understanding of the material. By assessing student understanding of the threshold concepts, instructors can ensure that students are developing the critical thinking skills and deep understanding necessary to succeed in the workforce and the digital age.

Educators can design learning acctivities and assessment methods based on Bloom's Taxonomy (*Image 2: Bloom's Taxonomy*), which focuses on the development of higher-order thinking skills and is similar to the DIKW pyramid(. By aligning threshold concepts with the six levels of cognitive learning - Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating - we can create a curriculum that encourages students to engage with the material in a more meaningful way and foster a deeper understanding of the subject.

Image 2: Bloom's Taxonomy



2.2 Practical Skills

In addition to teaching students threshold concepts, it is important to also teach them practical skills that are relevant to the subject area. While the understanding of threshold concepts is fundamental, practical skills are necessary to apply these concepts in real-world settings.

In some cases, the availability of advanced technologies and tools such as generative AI can make a deep understanding of threshold concepts less critical. However, it is still important to ensure that students have a solid foundation in the fundamental concepts of the subject area. This will enable them to understand the context of the tools and technologies they are using and make well-founded decisions about their application.

Incorporate practical skills through separate subjects or projects within the main course. The choice of technologies and tools should align with the threshold concepts and be relevant to the subject area. Educators can also provide opportunities for students to

apply these skills through internships, co-op programs, and other experiential learning opportunities.

Overall, striking a balance between teaching fundamental concepts and practical skills is key to preparing students for the workforce and the digital age.

3. What are Threshold Concepts?

Threshold concepts are key concepts in a particular discipline or subject area that are often difficult for students to understand but are essential for developing a deep understanding of the subject. Once students grasp these concepts, they can achieve a more profound and transformative understanding of the subject matter. According to (Cousin, 2015), threshold concepts can be seen as a "less is more" approach to curriculum design.

3.1 History

Threshold concepts were first introduced by Jan Meyer and Ray Land in 2003, and have since been widely used in educational research and practice. They argue that threshold concepts are transformative because they change how students think about a subject and provide a new perspective or framework for understanding it. “It represents a transformed way of understanding, or interpreting, or viewing something without which the learner cannot progress.“ (Meyer & Land, 2003, 1)

3.2 Defining Characteristics

Threshold concepts are often characterised by several features, including being:

Irreversible	Once students understand the concept, they cannot "unlearn" it or go back to their previous way of thinking.
Troublesome	Threshold concepts are often challenging for students to grasp, and they may struggle with them for some time before they finally "get it."
Integrative	Threshold concepts are often fundamental to a discipline and can help students connect and integrate different aspects of their learning.
Transformative	Understanding of threshold concepts can change how students see the world and provide a new perspective on the subject matter.

For more expansive descriptions please refer to “An Introduction to threshold concepts” (Cousin, 2015, #) and “Threshold Concepts and Troublesome Knowledge: linkages to ways of thinking and practising within the disciplines“ (Meyer & Land, 2003).

3.3 Examples

To provide a concrete illustration, (Meyer & Land, 2003, 3) present the example of a cook who gains a crucial insight into the concept of heat transfer as a function of temperature gradient, which is a fundamental threshold concept in physics. They invite readers to imagine a scenario where two identical cups of tea are poured, and the cook wants to cool down one of them as quickly as possible. The cook intuitively adds milk to the first cup immediately and waits for a few minutes before adding milk to the second cup. However, contrary to intuition, it is the second cup that becomes cooler faster. The authors explain that during the initial stages of cooling, the second cup, without milk, is hotter than the first cup with milk. Consequently, it loses more heat due to a steeper temperature gradient. Understanding this principle leads trainee chefs to shift their focus from ingredients to selecting appropriate pots and pans for specific dishes. This transformative understanding marks a significant initiation into the culinary culture.

Additional examples of threshold concepts across various disciplines include:

- Mathematics: Understanding the concept of proof.
- Biology: Grasping the concept of evolution by natural selection.
- History: Comprehending the concept of causation.
- Psychology: Embracing the concept of cognitive dissonance.

In teaching, educators can employ threshold concepts to assist students in identifying and grappling with these essential conceptual frameworks. By explicitly identifying threshold concepts and designing teaching strategies to facilitate student understanding, educators can foster a deeper and more transformative comprehension of the subject matter.

4. Course Design Implementation

In this chapter, we present a step-by-step guide to assist educators in transforming their course design to be centred around threshold concepts. Recognizing the significance of threshold concepts in promoting deep learning, this guide aims to provide a simplified framework that can be adapted to a variety of academic disciplines.

4.1 Identify Threshold Concepts

Start by identifying (Approximately 5-7 of) the most fundamental and transformative concepts in your subject area. It is also important to prioritize them to determine which concepts are the most essential for students to grasp and should be emphasized more heavily in the course design. This process may involve consulting with colleagues or conducting research to determine the most significant threshold concepts in your discipline.

Identification Tips

- They are unique to your discipline.
- Reflect on personal epiphanies that might reveal threshold concepts.
- Recognize that threshold concepts are value statements that represent a fundamental change in thinking.
- It helps to get an outsider's perspective to identify threshold concepts.

4.2 Develop learning outcomes based on threshold concepts

Once you have identified the threshold concepts in your subject area, develop learning outcomes based on these concepts. Learning outcomes should be specific, measurable, and aligned with the identified threshold concepts.

4.3 Design learning activities that focus on threshold concepts

Develop learning activities that are focused on the identified threshold concepts. These activities should be designed to help students understand and engage with these fundamental concepts.

In designing learning activities that focus on threshold concepts, instructors can use Bloom's Taxonomy as a guide. For instance, they may create activities that require students to remember and understand key concepts (Remembering and Understanding),

apply these concepts to solve problems (Applying), analyze different aspects of the concepts and their relationships (Analyzing), evaluate the effectiveness of different approaches (Evaluating), and create new solutions or perspectives based on their understanding (Creating).

4.4 Create assessments that measure understanding of threshold concepts

Create assessments that measure students' understanding of the identified threshold concepts. Assessments should be aligned with learning outcomes and designed to measure students' mastery of these fundamental concepts.

4.5 Integrate threshold concepts throughout the curriculum

Ensure that the identified threshold concepts are integrated throughout the curriculum, including lectures, readings, and assignments. By weaving these concepts throughout the curriculum, students will gain a deep and transformative understanding of the subject matter.

4.6 Implement and assess the course design

Implement the course design and assess its effectiveness. Collect feedback from students to determine the effectiveness of the course design, make adjustments as needed, and continue to improve the course design based on the feedback received.

One way to communicate the importance of threshold concepts is to share personal epiphanies or stories that demonstrate how these concepts have transformed thinking within the discipline. In addition, instructors can encourage students to reflect on their own experiences and identify threshold concepts that may have played a role in their own learning.

5. Assessment forms

The current educational program mainly focuses on the reproduction of information, which can now be easily done through AI. To ensure that students truly understand the threshold concepts and are able to apply them in various contexts, assessments should be aligned with learning outcomes and designed to measure higher-order thinking skills using Bloom's Taxonomy framework.

Strong opposition exists among the team on relying solely on paper assessments as proof of understanding threshold concepts, considering the widespread availability of AI technology. We will elaborate on how we came to that statement later on.

To create assessments that do measure students' understanding of threshold concepts, the following forms could be used.

5.1. Verbal Elaboration

Verbal elaboration can be used to assess students' understanding of the threshold concepts (Theobold, 2021). This form of assessment requires students to provide a verbal explanation of their written work, thereby demonstrating their understanding of the concepts. Multiple teachers and didactical experts have indicated that this method is effective in determining whether a student has a thorough understanding of the material.

One potential drawback of using this approach is that students' grades may be influenced by their ability to speak fluently and effectively explain the principles they have learned. This needs to be taken into account when opting for this method. (Theobold, 2021)

Originality

One of the potential challenges of relying solely on this method is the necessity for educators to consistently create a variety of unique exercises. This step is crucial to inhibit students from simply trading answers among themselves. Take, for instance, a situation where a whiteboard is deployed to evaluate a student's understanding of the concepts. In such scenarios, it becomes indispensable for the teachers to infuse a level of originality and creativity into their questioning tactics. These considerations are significant and must be meticulously deliberated when deciding upon the suitability of this teaching and evaluation approach.

Another problem during verbal assessments might be that it becomes crucial to assess a student's comprehension of the subject matter rather than their ability to simply read and explain comments within code. A student’s proficiency in explaining code comments doesn't necessarily reflect a deep understanding of the underlying concepts or problem-solving skills.[1]

Hence, assessors should encourage students to think beyond the specifics of the given code and delve into its broader implications and context. This approach promotes a more holistic understanding and application of coding skills, rather than mere recitation of explanations provided in the code comments. This nuanced evaluation of the students' understanding and application of coding skills can provide a more accurate representation of their true comprehension level.

An effective illustration of this approach can be found in the Machine Learning semester at Windesheim. Within this period, a formative assessment is already incorporated, serving to gauge the students' comprehension of the subject matter. This not only helps shape an understanding of students' grasp of the content but also mitigates the pressure associated with the final summative assessment.

[1] Pointed out during meetings with our teachers

Training

Given the rapid advancements in AI technologies, maintaining educational excellence at educational institutions requires our educators to stay abreast of these changes. Comprehensive assessor training ensures our teachers can effectively evaluate threshold concepts during student assessments and interviews. (Cardamone, 2023)

We strongly recommend intensifying such training to ensure that our educators remain current, effective, and ready to meet the challenges of the swiftly changing AI educational landscape.

5.2 Controlled Environment

To ensure that students are able to verify their understanding of the threshold concepts without relying on AI tools, a controlled environment assessment can be used for coding exams. This type of assessment creates a controlled and monitored environment where students can work on the exam, ensuring that they do not have access to external resources during the exam. The environment can allow access to static information such as Stack Overflow posts and web pages while monitoring and stopping traffic from AI tools like CoPilot and ChatGPT. This type of assessment ensures that students are able to demonstrate their understanding of the threshold concepts without relying on external AI tools.

Open Source Models & Blacklisting

It is important to acknowledge that the suggested approach is vulnerable to rapid changes and evolving circumstances. For instance, the availability of GPT-4 models that can be executed locally, facilitated by open-source models like GPT4All, highlights the need for a more comprehensive strategy. Relying solely on blacklisting specific URLs, such as chat.openai.com, is likely to be ineffective as numerous alternative platforms continue to emerge. Students might even resort to running their own cloned versions by utilizing open-source ChatGPT alternatives on private domains.

Furthermore, the emergence of a ChatGPT clone in the integrated development environment (IDE), such as Github Copilot Chat, poses additional challenges in preventing unauthorized usage.

Virtual Environments

One alternative approach to address suspicions of unauthorized AI usage during exams is to record students' screens for later review with tools such as Proctorio. When using this one should consider certain concerns regarding privacy, technical feasibility, accuracy, and resource intensity.

6. Teacher Approach

We would like to highlight the importance of transforming the teaching approach in classrooms, particularly in regard to student engagement during lessons (if this practice has not yet been adopted). Traditional paper assessments may not be sufficient to evaluate a student's understanding completely. As a result, it is essential for teachers to establish a relationship with their students that allows them to accurately gauge the extent of each student's comprehension.

Currently, many lessons are primarily lecture-based, with teachers delivering information while students passively listen. This format often lacks meaningful interaction between students and instructors. (Aupperlee, 2021)

To enhance the learning experience, we propose adopting a more interactive approach to teaching. Encouraging students to actively participate in class discussions, even if they are still struggling with the subject matter, can promote deeper understanding. By engaging in conversation about the topics being studied, teachers can better assess students' knowledge and provide tailored support as needed.

As students ourselves, we can attest to the value of a more engaging and collaborative learning environment. We strongly believe that these changes are necessary for educational programs to remain effective and relevant in today's dynamic world where AI plays a more important role.

The process of getting a more interactive learning environment is a process that started long before AI was a thing. Therefore we see this moment as a perfect opportunity to adopt this strategy and implement the change needed.

7. Integrating AI into lessons and projects

Lessons

While generative AI is often viewed sceptically in educational contexts, we perceive a vast potential in harnessing this technology for enhanced learning outcomes. When thoughtfully implemented, generative AI can transform the educational landscape, enriching lesson content, tailoring the learning experience to each student's needs, and providing a wealth of resources that can facilitate a deeper understanding of the threshold concepts. Beyond merely automating tasks, generative AI stands as a powerful ally in education, fostering an engaging and interactive learning environment that aligns with the evolving digital age. (Su & Yang, 2023)

Use cases of this technique can be found on windesheim.tech/generative-ai.

For instance, consider the use of generative AI in personalized learning. Each student learns at a unique pace and engages with educational content differently. Generative AI can synthesize these individual learning patterns to deliver personalized materials, aiding in the comprehension of complex subjects and catering to diverse learning styles. (Su & Yang, 2023)

Generative AI can also provide new forms of assessment, offering educators detailed insight into a student's performance. By analyzing a learner's progress, AI can produce comprehensive, personalized reports that help teachers identify areas needing attention, thereby supporting targeted instruction.

Furthermore, generative AI tools can facilitate round-the-clock learning support. AI-powered chatbots, for example, can answer student queries outside of classroom hours, giving students immediate responses and continuous learning support. These bots can answer a range of questions, from homework queries to deeper conceptual discussions. (Su & Yang, 2023)

Projects

With the rising integration of AI in projects, including advanced tools like Github Copilot and ChatGPT, we anticipate a meaningful uplift in productivity, as projected by Github (Github, 2022). This enhancement isn't just theoretical - we've witnessed it first-hand within our IT educational program, as our students are learning to utilize these tools to their maximum capacity.

Given this expected productivity surge (a rise of 55%, as projected by Github), we believe it's viable to raise the standards of educational programs. However, this elevation in expectations comes with a commitment to provide robust support, ensuring every student can meet these new standards without undue stress (OpenAI, n.d.) This should be something that has to be considered and looked out for.

To ensure every student can meet these new standards, we propose implementing a workshop to acquaint students, teachers, and faculty alike with these cutting-edge technologies. This workshop should be kept up-to-date with the latest technologies due to the rapid improvement of these technologies. (Cardamone, 2023)

The goal is not just to produce more work in the same amount of time, but to equip students with the skills to create greater business value in an evolving technological landscape. We are moving towards a future where AI proficiency is integral, and we should be committed to preparing our students for this reality. (Microsoft, 2023)

8. Further Remarks

It is important to note that the advice provided in this document is intended for a 2-3 year timeline. However, it is crucial to emphasize the importance of continuous re-evaluation and adaptation as technology advances and the educational landscape evolves.

In the future, technology may become so sophisticated that the need for practising a skill may disappear entirely. By committing to ongoing assessment and adaptation of the institution's purpose and approach, education institutions can ensure its education remains relevant and effective in the face of changing technologies.

To ensure informed decision-making, it is crucial for education institutions to remain updated on emerging technologies. In light of this, we strongly recommend designating a responsible individual or team to consistently monitor and stay abreast of the latest advancements. The field of generative AI, in particular, is highly susceptible to rapid and unexpected changes.

By actively keeping relevant commissions, groups, and individuals up-to-speed, education institutions will be better equipped to make appropriate decisions aligned with the dynamic nature of this domain.

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