The Neuroscience of Emotions and the Role Emotions Play in Learning

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Abstract

The relationship between emotions and learning has always been of great interest in the field of educational neuroscience. Advancements in brain imaging techniques have given us better understanding on the role these affective components have in various cognitive processes including memory, attention, decision-making and social functioning (Immordino-Yang & Damasio, 2007). As educators and researchers in the field of educational neuroscience, our main objective in this paper is to bridge the gap between education and neuroscience. Applying scientific research to the classroom is not a straightforward process (Shearer, 2020; Howard-Jones, 2014). However, we believe that educators can benefit a lot when exposed to scientific research in order to base their classroom practice on solid grounds. Additionally, educators have a lot to offer from their first-hand experience in schools, especially when it comes to the role of emotions in teaching and learning. A meta-analysis of current research in the field will be presented to highlight the important role of emotions in learning. By understanding this role, we aim to inform and transform educational practices in the local scenario and beyond.

Keywords

Emotions, Learning, Educational Neuroscience, Affective and Cognitive Brain Processes

Introduction

As social beings, emotions serve a very important function in our life as humans. They affect diverse aspects of life, ranging from simple decisions taken on a daily basis to more complex phenomena, such as building relationships and academic learning. By simply spending a day in a classroom, one can observe the impact of the emotional states of all stakeholders involved, mainly the

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students, the educators, and even the general classroom atmosphere. Due to recent advancements in neuroscientific methods throughout the past years, emotions can now be studied on a much deeper level (Immordino-Yang & Damasio, 2007). This has made it possible for researchers to not only rely on observations of humans in action, and carry out lesion studies in the case of individuals with particular challenges or post-mortem studies of the brain, but also to observe neuronal activity whilst the person is in action. Therefore, like various other brain processes, emotions have and are being studied in a way that allows for a much more significant understanding to take place.

As teachers specialising in the field of educational neuroscience, we felt the need to write this paper in order to bridge the gap between education and neuroscience. We believe that as emotions have a crucial role to play in the teaching and learning experience of all our students, we need to make the most out of our specialisation in both fields in order to set a common ground which enables knowledge to be shared and mutual communication to occur. As scientists can provide educators with important findings and research, educators can share their experiences and direct observations that allow for ecological validity, which cannot always be possible in formal lab and clinical settings. Despite the fact that adopting neuroscientific findings to education should be carried out with caution, as misconceptions and neuromyths can easily result (Howard-Jones, 2014), both fields can benefit from each other if professionals are clear about common terminology used and are able to communicate in an empowering and secure environment. Thus, through the writing of this paper, we would not only like to provide an analytical overview of the literature regarding the neuroscience of emotions and their role in learning, but we would also like to pave the way for local educators, policymakers, researchers and scientists to follow suit.

Literature review

"One ought to hold on to one's heart; for if one lets it go, one soon loses control of the head too." (Friedrich Nietzsche)

Emotions have always played a crucial role in human behaviour. The conventional, dichotomist approach of the heart against the brain, emotion against cognition, has led to an array of misconceptions that underestimate the relationship between the intellectual and the affective. Dating back to the times of ancient Greece, thinking and feeling were viewed as opposing forces intertwined in a constant battle for control over the human psyche (McCraty, 2003). Whereas intellect was always considered to be a positive attribute, emotions were mostly associated with the weak and regarded as the main source of irrational behaviour, especially in the post-Cartesian and the post-Kantian approaches towards the mind (Damasio, 2006). Additionally, the important role that the brain plays in the rise of emotions and their processing has not always been understood. However, through the years, the perspective towards emotions has changed. This has brought along with it a deeper understanding of the connection, rather than battle, between the cognitive and the affective processes.

The Study of Emotions

Despite the fact that various 19th-century researchers showed interest in studying emotions, only a few researchers such as Sigmund Freud, Charles Darwin and William James attempted to truly delve deeper throughout the past century (Damasio, 2006). However, in recent years, numerous researchers from various fields such as philosophy, psychology and sociology have been showing more interest in understanding emotions and studying affective processes (Ekman, 2016). A few parallel changes which were taking place made the study of emotions possible in a more profound manner, after the neglect which took place during the 20th century. First of all, the adoption of an evolutionary perspective of the brain and mind allowed researchers to understand better certain mental phenomena and their adaptation through the years. Secondly, the link between the nervous system, the immune system and the endocrine system was given more importance in the cognitive sciences. Consequently, the third change which occurred was related to an awareness of the complex relationship between the mind and the body, rather than a sole link of the mind to the brain. The notion of the living organism (as presented by Goldstein, 1933) was present well before such changes started to occur. However, this was rarely taken into consideration. Such shifts in approach led researchers to look at emotions in a different light. As the "highest-order direct expressions of bioregulation in complex organisms" (Damasio, 2006, p. 85), emotions could not be left out by neuroscientists and cognitive scientists when studying the interaction of humans with their environment and any related disorders which tend to lead to a lot of human suffering in society. Additionally, processing such emotions is of utmost importance for the survival of complex beings, like humans.

Besides the essential role that emotions play in memory, researchers started to realise the important part they play in decision-making and reasoning. From the instinctive behaviour that leads animals to escape dangerous situations, or to approach a favourable one, to the more complex processes that led humans to flourish in various areas of civilisation, emotions are always involved in such cognitive processes.

The main method of investigation was originally based on the observation of human behaviour (Jeffery, 2014). However, a more experimental approach has been adopted in time, enabling a more profound understanding of what emotions truly involve. Additionally, the development of modern neuroimaging techniques has made it possible for brain activity to be observed in real time, especially the observation of the limbic system, which seems to be mostly related to the neurobiology of emotions. Unlike alternative neuroscientific methods that relied mostly on animal studies, invasive lesion investigations (mainly in patients with acquired or congenital brain lesions) or post-mortem methods (Dolcos & Denkova, 2014), contemporary neuroscientific methods like EEG, fMRI and PET scans enable researchers to study neuronal activity in various parts of the brain in a living person at a particular point in time (Kober et al., 2008). This has led to numerous opportunities for scientists to not only rely on observations and self-report psychological assessments, but also tap into the physiological effects and neuronal activity underpinning emotional processes. Despite the fact that each and every technique has its own advantages and limitations, an interdisciplinary approach makes it possible for a more holistic understanding to be attained. In order for this to be possible, researchers from different fields need to seek common grounds and deal with lexicological barriers to be able to share knowledge and understand better such affective processes (Adolphs, 2017). All disciplines involved need to be considered as important in what they can offer in order to substantiate knowledge about emotions. Effective communication between professionals is essential in order for the right interpretation of research findings to be possible.

Through this paper, we aim to bridge the gap between the fields of educational neuroscience, psychology and education in order to understand better the role that emotions play in the teaching and learning experience. As educators ourselves, we attempt to use our specialisation in cognitive science and educational neuroscience to inform teaching practices and also raise awareness regarding the importance of the adoption of such an interdisciplinary approach.

Adopting an Interdisciplinary, Multi-Method Approach

According to Druckman et al. (2011), experimental findings drive the development of theories. For example, Damasio (2005) highlighted how fMRI experiments on patients with particular brain injuries showed how emotions assisted the process of reasoning. Prior to the possibility of having empirical evidence regarding the foundations of such processes, such link at a neurobiological level could not be achieved. Franks (2006) also highlights the important role that these findings have in challenging traditional sociological and psychological views which can expand theory further. However, this does not mean that observations and other means of research are not also important as these tend to substantiate the neuroscientific findings and even improve ecological validity. Therefore, by once again referring to the fMRI experiments highlighted by Damasio (2005), an effective researcher would not limit the study to the data acquired from the fMRI scans, but also supplement it with behavioural observations to understand better the complex relationship between emotions and the reasoning process engaged by patients when asked to participate in specific tasks through their everyday life.

Even though in this paper we aim to highlight the neuroscience behind the emotional brain and its role in teaching and learning, we value the importance of looking at emotions from a holistic point of view, rather than as mere neurobiological processes occurring as a reflex to certain stimuli. The complex nature of this field of study is reflected from the moment one attempts to define it (Celeghin et al., 2017), which is what the next section looks into.

Attempting to Define Emotions

“Everyone knows what an emotion is, until asked to give a definition. Then, it seems, no one knows.” (Fehr & Russell, 1984, p. 464)

Despite the advancement in the study of emotions in various fields, there still seems to be a lack of a general consensus between researchers regarding the definition of emotions in a scientific framework. In fact, back in 1981, Kleinginna and Kleinginna included 92 definitions and 9 varying descriptions of emotions proposed by different scientists in their research paper. Besides the variety in taxonomies related to emotions, different approaches have been and are being adopted in order to understand what emotions truly are.

From a neuroscientific perspective, emotions can be considered as the specific neural and physiological shifts in a living organism in response to stimuli in the environment (Fossati, 2012). Two particular brain pathway models are highlighted as essential for emotional processing to be possible. These include the cortical pathway and the subcortical pathway (Garvert et al., 2014). Whereas the cortical pathway is involved in the conscious processing of emotions, the subcortical pathway is related to the subconscious processing and automatic reflexes in relation to various emotional states. In the cortical pathway, visual information is passed from the retina to the primary visual cortex through the lateral geniculate nucleus. The information is then transmitted to the temporalis inferior regions onto the amygdala (Li et al., 2020). On the other hand, the subcortical pathway involves the transfer of visual data to the amygdala through the epithalamus and the pulvinar, the latter being essential in the rapid transfer of information which enables quick behavioural and emotional responses (De Gelder et al., 2011; Tamietto et al., 2009). This reflects the complexity of effective processing in the human brain.

The idea of basic emotions, the view of the existence of several primary emotions, typically including sadness, joy, fear, anger, disgust and surprise, is debated amongst various researchers who adopt distinctive perspectives (Tracy & Randles, 2011). Supporters of the theory of basic emotions, including Izard, Ekman, Plutchik and Tomkins amongst others, have been highly influenced by the evolutionary approach introduced by Darwin (as cited in Celeghin et al., 2017). They believe that such emotions have developed automatically in order to allow organisms to interact with their environment and respond effectively to various situations with the primary aim of survival (Shariff & Tracy, 2011). On the other hand, arguments against such innateness of basic emotions have been proposed by various psychological construction theories. They believe that emotional meaning is generated by other psychological operations, including attention, perception and memory based on numerous external factors like linguistic and social influences (Barrett & Russell, 2015). For instance, the Conceptual Act Theory suggests that emotions are the result of the merging between physical sensations in both the self and others and the cognitive and perceptual process leading to the creation of emotional experiences (Barrett, 2014). Therefore, the definition of what emotions accurately are is based on the perspective adopted by the researcher. This is of utmost importance when attempting to understand their role in teaching and learning.

The role of emotions in teaching & learning

Even though there are various approaches adopted in this particular field (Panksepp, 2004), most theories seem to agree that emotions and their processing are crucial tools for not only survival, but also living and functioning effectively in modern society (LeDoux, 2012). Research is portraying a clearer picture of the influences that such affective processes have on cognitive functions, including attention, perception, decision-making and memory (Immordino-Yang & Damasio, 2007). Such a link is of utmost importance for education. In fact, emotions have been recognised as essential precursors to student learning and school achievement (Pekrun & Linnenbrink-Garcia, 2014; Schutz & Pekrun, 2007). Zull (2006) also emphasises the fact that "emotion is the foundation of learning" (p. 7). Therefore, it is of utmost importance that emotions are taken into consideration when curricula are being structured and lessons are being planned. Additionally, emotions are also crucial as a component of teaching (Hosotani & Imai-Matsumura, 2011). Multiple research studies have highlighted that the emotional state of the teacher also leaves a huge impact on the teaching and learning process (Yin et al., 2017; Scott & Sutton, 2009; Uitto et al., 2015). Both the awareness of the particular emotions of the teacher and the way such emotions are processed and expressed affect the quality of the teaching and even the learning experience of the students (Srinivasan, 2015; King & Chen, 2019). Therefore, it is not enough to focus on the emotional state of the students or the teacher only but also on the general emotional infusion in the classroom setting (Chen, 2019).

Studies have shown that positive emotions such as pride, hope and happiness seem to play a crucial role in learning motivation (Pekrun et al., 2002). Subsequently, this affects students' academic performance and even their learning behaviour (Goetz et al., 2008). Studies by Fredrickson and Branigan (2005) and Villavicencio and Bernardo (2013) both reflect the positive influence that such emotions can have on self-regulation and cognitive flexibility which are crucial precursors for various skills such as problem-solving, to be fully developed (Li et al., 2020). In order to understand well the role of the emotional brain, it is essential that the various executive functions involved in learning are also reflected upon from a neuroscientific perspective.

Executive Functions

The executive control functions, mainly composed of working memory, cognitive flexibility, and self-regulation, are imperative for education and school learning. Executive functions allow students to hold information in their mind, shift or sustain attention as needed, set priorities, and manage to focus on completing set tasks by the instructor (Beaty et al., 2015). This "attentional and executive control is intimately linked to learning processes, as intrinsically limited attentional capacities are better focused on relevant information. Emotions also facilitate encoding and help retrieve information efficiently" (Tyng et al., 2017, p. 1). The influence that emotion has on these cognitive processes, particularly how it impacts working memory, selective attention and transfer of learning, is vital to building educational practices that place the students' social-emotional learning at the forefront. Despite the clear link between emotion, executive functions and learning, there is still a lot to learn about this association. For a long time, learning was mainly studied in terms of cognition and motivation and, as a result, many educational theories overlooked the affective processes in this regard (Hascher, 2010).

Working Memory

Models of working memory and the ways it affects our processing and learning faculties has long been researched by psychologists and education professionals. At a glance, working memory denotes our ability to jot down pieces of information in our minds and process them simultaneously (Baddeley, 1992). It provides a "mental workspace or jotting pad" where we can think about information that we come across in our daily activities (Gathercole & Alloway, 2008). We use working memory in all sorts of tasks, from following directions by a stranger en route for our destination or calculating the amount of money spent in a supermarket, to academic tasks such as writing, reading and problem-solving. This memory system is divided into three sub-components: the central executive, which is mainly involved with attention control and higher mental processes, and two other short-term memory systems which feed and interact with the central executive, namely, the visuo-spatial short-term memory and the verbal short-term memory (Baddeley, 1992). The key function of the central executive is to bridge with one, or both, of the two short-term memory systems to organise more effortful mental processing. It is also responsible for controlling and switching attention (Gathercole & Alloway, 2008;

Swanson & Siegel, 2001). The central executive is not only linked to the short-term memory storage systems, but it is also able to integrate information from long-term memory. This enables us to reduce our dependence on a very limited storage by retrieving information from past experiences. The central executive, alongside the two short-term memory systems, provides a structure that is crucial for all sorts of academic work, and is a very strong predictor of academic performance (Masoura, 2006).

Engle (2002) argues that the main deficit in children with learning difficulties in the executive system is the inability to regulate attention. It is not a question of how many items an individual can store, but rather the "ability to control attention to maintain information in an active, quickly retrievable state" (p. 20). Greater abilities in executive functioning indicate an aptitude to focus on selected material or disregard incoming information while working on the task at hand. Swanson and Siegel (2001) claim that this "controlled attention" is characterised by the ability to hold on to information, even when faced with distractions, in order to successfully complete a piece of work (p. 19). The executive system must make adjustments to modify and reprioritise tasks. These adjustments include selective attention on foci and inhibiting other stimuli (Swanson & Siegel, 2001).

Working Memory and Emotions

The prefrontal cortex is linked with cognitive functions such as problem-solving, planning, reasoning and selective attention, and is also thought to involve a major role in working memory itself (Barbey et al., 2009). The prefrontal cortex is also intimately linked with subcortical regions of the brain in the limbic system, including the amygdala, allowing emotional processing to play an essential role in working memory, long-term memory and retrieval (Simons & Spiers, 2003). A number of findings also suggest that when the amygdala encodes emotional information, it enhances memory processes and makes retrieval more efficient (Richter-Levin & Akirav, 2000). This research seems to suggest that whenever the prefrontal cortex involves regions in the limbic system through emotionally stimulating events, information is consolidated and remembered better than during emotionally neutral events. Recently acquired information leads to the new formation of connections between neurons, and emotion also seems to regulate regions which store long-term memories (McGaugh, 2004). This inter-arching link between working memory, retrieval, and emotion has enormous implications on our education and schooling methods, as emotions appear to be directly involved in executive functions that trigger attention and interest, and subsequently, the accuracy of recall of emotionally charged lessons. This is further corroborated by research from Vuilleumier (2005) that argues that during emotional processing, the amygdala activates frontal regions and parts of the parietal lobe that are involved in attention control, thus enhancing the ability to focus. This indicates that emotional stimuli trigger more active attention by engaging working memory systems, allowing the efficient processing and recall of accurate information.

Positive emotions make learning easier and further promote learning and academic achievement. This is facilitated by both the improvement in working memory and enhanced levels of satisfaction and motivation and by the learning materials being used (Um et al., 2012). The attention and motivation factors also include curiosity, which encourages further questioning, exploration and interest in learning, all of which pave the way for long-term retention (Oudeyer et al., 2016). Attention is always inclined towards emotionally positive events and teaching, and in turn, this increases the possibility of emotional information being stored and successfully retrieved from long-term memory (Vuilleumier, 2005).

When looking at emotional well-being and the effects of relationships, family and school environment, research has shown that positive emotions and well-being trigger genetic markers that promote healthy brain development, whereas negative emotions such as stress and loneliness work in the opposite direction and stifle brain development (Immordino-Yang et al., 2019; Zilkha & Kimchi, 2018). Threatening emotional well-being directly affects neural functioning and brain physiology and takes up resources from executive functions and working memory, which would then in turn directly impact academic performance (Beilock et al., 2007).

Classroom Implications and Professional Practice

The research discussed above has strong implications for the professional practice of educators and the work carried out in classrooms. Although research in neuroscience and education never tries to undo existing good practices and the individual teacher contribution, we can use these findings in emotional neuroscience to direct practitioners to make the most of the lesson time available.

The attention and working memory of our audience seems to be much shorter than we sometimes believe or give credit for. Our attention during lesson time starts to increase at the beginning of instruction and reaches a peak after around 10–15 minutes, taking a turn for the worse after this time period when our selective attention starts finding other "interesting" thoughts to wander off to and the "torment" of the lesson begins (Medina, 2014). Although research in attention span has at times yielded inconclusive results (Keller et al., 2020), most experts agree that students cannot mentally focus for increments longer than 15 minutes, and it is clearly inefficient to expect our students to focus their attention continuously for longer periods of time (Bradbury, 2016).

The short span of this attention window can in a way discourage educators, but we can also look at what the discussed research on emotions and learning is telling us in terms of classroom practice. By looking at the imperative role that emotions play in reacquiring attention and inducing motivation (Oudeyer et al., 2016), it makes sense that instead of looking at a lesson as a whole 45 minutes, 1 hour or 2 hours, we start looking at instruction time in sections of 10–15 minutes that can be "reset" by an emotionally charged activity or narrative that helps us move on to the next segment by recapturing executive functions. This gives the instructor a window of opportunity to break away from this short attention period and then doing it again for subsequent parts of the lesson. Emotions, including curiosity, happiness, laughter, enthusiasm, incredulity, and nostalgia, can all work to involve the limbic systems discussed earlier and focus our audience's attention back on task. These emotions can be included through narratives, activities, investigations and any other events in the classroom which can harness emotion-seeking systems.

The amygdala, deep in the subcortical brain, is involved in the release of specific neurotransmitters such as dopamine where emotion is concerned (Medina, 2014). As the audience's attention and executive functions start to plunge after the 15-minute period, recruiting the amygdala can make the difference in keeping the audience engaged for the next part of the lesson.

Transfer of Learning

The benefits of placing the learner's emotional experiences and learning at the forefront do not stop at the executive functions and recall level. When students show improvement in interest and attention, the odds of that knowledge being transferred also increases. As Thomas et al. (2020) argue in their concluding chapter of educational neuroscience, when practices involving emotion and students' social experiences are introduced in learning, deep thinking and transfer of learning are much more likely to happen, compared to when students are only learning to satisfy an arbitrary goal.

In an excellent review on the science of learning, Halpern and Hakel (2003) argue that the main reason behind education, perhaps the only one, is the transfer of learning. In other words, "the assumption that knowledge, skills, and attitudes learned will be recalled accurately, and will be used in some other context at some time in the future" (Halpern & Hakel, 2003, p. 38). Research in cognitive science has shown through the years that knowledge gained in emotionally motivating and engaging situations tends to be more deeply rooted and more easily accessible than that learnt through memorisation (Kolodner, 1997). For learning to take place, an individual must match his new situations to what is stored in memory and find what is most similarly applicable (Kolodner, 1997). In doing so, a student analyses the results of his own actions and inserts new experiences in memory, which can then be used elsewhere.

Barnett and Ceci (2002) argue that much of the financial and human investment in education is justified by the fact that schooling helps cultivate certain skills in individuals that they can then use to become productive members of society. The researchers rightly state that items taught in school have to be transferred to other skill sets that will be required outside school. The ability to extend what has been learnt in one context to a new one from a different domain is known as far transfer (Barnett & Ceci, 2002). When students successfully retrieve an item during the retention phase, they are more likely to correctly answer the related transfer question, confirming that an increase in retention ability can indeed promote transfer of learning (Butler, 2010). This positive affect allows to further extrapolate the positive effects of emotions in learning, which does not just stop at the recall level but also extends to far transfer.

Education is only relevant to our next generations if it can give them the right abilities to retain information beyond their schooling years and to use that information to abstract and transfer it across multiple domains. If such an objective is attained, then, education will become more relevant to all individuals we come in contact with at school.

Emotions and Brain Development

Growth and brain development is not only a question of the brain gaining mass and an increasing number of synapses, but rather of an intricate process of reorganisation and pruning that reflects the individual's life experiences and their environment (Gogtay et al., 2004). This means that as an individual engages with other people, challenges, events and relationships, their brain development is shaped by the same experiences. With the right opportunities and support, children start to engage with their social and physical worlds through their thoughts and the emotions that they feel. These patterns of thoughts and emotions guide and shape brain development over time and influence traits like intelligence and executive functions in the future (Immordino-Yang et al., 2019). Jones et al. (2018) argue that since thinking and brain development are so intertwined, it makes sense to examine brain development at different stages and develop strategies to support students starting from the early years throughout all schooling levels.

In preschool years, brain development is characterised by motor coordination, language development, and goal-directed behaviours that allow young children to communicate with those around them, coordinate movements and pay attention (Gopnik et al., 2000). Using emotions as a form of communication is key at this age. From physical milestones such as taking one's first steps, to talking and potty training, learning requires predictable, calm interactions with loving adults and an emotionally safe environment with plenty of opportunities to explore and share (Shonkoff, 2011). Figuring out how to make friends, engage, play, and take turns is highly dependent on social-emotional skills and contributes to emotional learning that is imperative for executive functions and schooling such as self-regulating, determination and motivation. Regular routines typically employed in play school and home settings such as indoors and outdoors playtime, snack time, story time and circle time all provide for a balance of activities, showing both predictability and novelty that allow young children to develop emotional and social skills (Immordino-Yang et al., 2019).

During adolescence, the brain is characterised by the maturing of the amygdala and other reward structures in the subcortical brain that lead to more sensitivity to the presence of peers, reputation, social cues and interaction (Albert et al., 2013). The prefrontal cortex, key to executive functions, decision-making and planning, begins a period of accelerated development, new synapses and pruning that further increase its connections with the amygdala and other regions of the limbic system involved in emotions, reward and social sensitivity (Blakemore, 2018). Supporting adolescents in school settings is crucial at this age, as they build long-lasting relationships with their peers and with adults they come across such as teachers, guidance and psycho-social teams that can customise instruction and support them (Osher & Kendziora, 2010). Such school settings allow these young adults to develop skills such as problem-solving, critical thinking and metacognition, leading them to reflect, further develop their work and contemplate on their own thinking.

Concluding thoughts

After discussing the literature on how emotions affect executive functioning and brain development, and their implications in school scenarios, we are led to question how we can prioritise this niche of neuroscience and use it for the benefit of the children and young adults entrusted in our care. All our brain's neural networks seem to support emotional and cognitive processes. Additionally, we can also link the effects of our past emotional and social experiences to such neural networks (Immordino-Yang et al., 2019). Learning involves working memory, attention, processing information and making logical relationships, and all this processing is neurologically stimulated and driven by emotions (Immordino-Yang & Damasio, 2007). Social, emotional and other cognitive processes all contribute to one's learning and abilities across the schooling years.

When students are emotionally and socially regulated, they can think better and progress more in terms of scholarly achievement and cognition (Immordino-Yang et al., 2019), making it clear that attending and prioritising social-emotional experiences both in the classroom setting and the school environment is a necessity for all the students in our responsibility. This should be a guiding principle and crucial point in all discussions and policy build-up in education, and should be reflected in the teaching, school ethos, autonomy and community aspect of our educational institutions.

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