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Calculus Adapted for Neurodivergent Students: A Comparative Study

| Cálculo adaptado para estudiantes neurodivergentes: un estudio comparativo |

| Cálculo adaptado para estudantes neurodivergentes: um estudo comparativo |

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Abstract: The study investigates the possibility of redesigning standard university-level Calculus to suit neurodivergent students, including ADHD, autism, dyslexic, and cognitively similar patterns. Traditional Calculus instruction relies on abstraction, quick thinking, and memorization—mechanisms that render students with different learning patterns invisible. This comparative qualitative research design-based study compares findings from five USA, Canadian, German, and Dutch universities. The research, based on interviews, observation of classrooms, and document analysis, identifies pockets of barriers in current pedagogical models. The research identifies that accommodations in the formal environment (e.g., extra time) provide procedural support, yet rarely address underlying instructional misalignments.

Keywords: Neurodiversity, Inclusive Pedagogy, Calculus Education, Universal Design for Learning

Resumen: El estudio investiga la posibilidad de rediseñar el cálculo universitario estándar para adaptarlo a estudiantes neurodivergentes, como TDAH, autismo, dislexia y estudiantes con patrones cognitivos similares. La enseñanza tradicional del cálculo se basa en la abstracción, el pensamiento rápido y la memorización, mecanismos que invisibilizan a los estudiantes con diferentes patrones de aprendizaje. Este estudio comparativo cualitativo, basado en diseño de investigación, compara los hallazgos de cinco universidades de Estados Unidos, Canadá, Alemania y los Países Bajos. La investigación, basada en entrevistas, observación de aulas y análisis de documentos, identifica barreras en los modelos pedagógicos actuales. La investigación identifica que las adaptaciones en el entorno formal (p. ej., tiempo adicional) brindan apoyo procedimental, pero rara vez abordan las desalineaciones instruccionales subyacentes.

Palabras Clave: Neurodiversidad, Pedagogía Inclusiva, Educación en Cálculo, Diseño Universal para el Aprendizaje

Resumo: O estudo investiga a possibilidade de redesenhar o cálculo universitário padrão para adaptá-lo a estudantes neurodivergentes, como aqueles com TDAH, autismo, dislexia e com padrões cognitivos semelhantes. O ensino tradicional de cálculo baseia-se na abstração, no pensamento rápido e na

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memorização, mecanismos que tendem a invisibilizar estudantes com diferentes formas de aprendizagem. Este estudo comparativo qualitativo, fundamentado em pesquisa baseada em design, compara os achados de cinco universidades dos Estados Unidos, Canadá, Alemanha e Países Baixos. A investigação, baseada em entrevistas, observação em sala de aula e análise documental, identifica barreiras nos modelos pedagógicos atuais. Os resultados indicam que as adaptações no ambiente formal (por exemplo, tempo adicional) oferecem apoio procedimental, mas raramente abordam os desalinhamentos instrucionais subjacentes.

Palavras-chave: Neurodiversidade, Pedagogia Inclusiva, Educação em Cálculo, Desenho Universal para a Aprendizagem

1. Introduction

For others, Calculus has served as a Mathematics education anchor and gateway to STEM professions. While Calculus is an anchor course, Calculus courses are also the most challenging and exclusionary courses for most students. Their unusually high rates of failure, withdrawal, and discouragement have been troubling policymakers and educators for several years (Villarreal, 2012). While a great deal of effort has gone into codifying general Mathematics pedagogy, less has gone into how Calculus can and should be adapted for students whose thinking styles vary from neurotypical norms (Rojas-Ferreira, 2016). Included among them are neurodivergent students—a broad and diverse category which includes students who have autism spectrum disorder (ASD), attention deficit hyperactivity disorder (ADHD), dyslexia, dyscalculia, dyspraxia, and other neurological variations. The long-term underrepresentation and over-attrition of more Mathematics neurodivergent students are of serious concern regarding the Calculus course of study, its epistemologies, and the institutional arrangements that make winners and losers (Alsina & Coronata, 2014).

1.1. Pedagogical Conflict and Cognitive Styles

The problem is complicated. Its basis is a conflict between traditional ways of teaching Calculus and the cognitive styles of neurodivergent students. Traditional calculus teaching normally demands and penalizes some way of thinking: linear thinking, the speed of symbolic computation, multitasking pressure, memorization by rote, and abstract generalization. Most neurodivergent students do not (Alsina, 2019). For instance, dyscalculic students may have difficulties with numerical relationships; ADHD individuals with sustained attention in lecture-type formats; autistic students with more concrete contextualization and pattern-finding strategies; and dyslexic learners with problem setups dense with text and notational overloading (Alsina, 2019). These variations in mind are intellectual deficit is not but variations in people's comprehension, organization, and recall of mathematical ideas. Failure to recognize and accommodate these variations in Calculus courses will more than likely result in academic marginalization, yet numerous neurodivergent students have Mathematics thinking capabilities such as visual-spatial thinking, divergent problem solving, and sustained attention in attentional areas (Rodríguez Gallegos, 2017).

1.2. The Deficit Model and Accommodations

Today's model of university education is with the accrual of neurodiversity as under a disability services and legal accommodations system that puts neurodivergent students into the role of being held accountable to become "supported" in order to become enabled to enter pre-existing curriculum. The deficit model is also articulated far too often in one-to-one accommodations (i.e., test time extension, note-taking support, low-distraction environments) and not at all in pedagogical or curricular structural redesign (Soto, 2008). The accommodations requested are inadequate. They do not address the epistemological and pedagogical paradigms undergirding the exclusion of neurodivergent students from educational community full membership. Furthermore, such accommodations are also frequently coupled with the requirement for formal diagnoses, which are burdensome or expensive to seek out, particularly for marginalized racial, socioeconomic, or cultural group students. The model therefore does not just crush pedagogical imagination but instates ingrained disparities (Valero & García, 2014).

1.3. Research Gap and Theoretical Framework

Despite growing public awareness of neurodiversity as social movement and concept, research addressing in systematic terms how Calculus education could be structured to include instead of merely accommodate students who are neurodivergent is scarce (Bishop, 2000). Most of the dialogue about inclusive Mathematics instruction is couched in elementary school or secondary school, and if there is any mention of neurodivergent students at postsecondary Mathematics, remedial is where it happens. Something has to change from remediation to redesign—redesigning systems, not students. Missing from the literature is a theory-grounded, empirically informed, and systematic analysis of to what extent Calculus education can be inclusive in principle and practice (Astudillo, 2005).

The research bases itself on three theoretical models: 1) the Neurodiversity paradigm, which views differences in the neurológicos as natural and not as something to fix but rather as something to be respected; 2) the Universal Design for Learning (UDL), whose principles attempt to remove the obstacles of the curriculum through multiple representations, expressions, and engagement; and 3) the Pedagogy Culturalmente Responsiva, from the conviction of making the teaching available to the multiple ways of thinking, valuing the richness of the differentiated mathematical ways of thinking (Rodríguez Gallegos, 2017).

Second, recent research on inclusive STEM education spans wide national or monolingual terrain, and says little about how diversity of cultural, institutional, and policy contexts shapes research on neurodiversity. Pedagogy in the other hemisphere of the world, Europe and North America, is also very place-to-place variable in how it conceives disability, structures curriculum, prepares teachers, and implements policies of accessibility.

These differences offer a firm basis for comparative scholarship (Giménez et al., 2007). While the United States and Canada focus on personal rights and formal accommodation with disability services, most of Europe envisions inclusion more broadly through universal design and policy reform at the systems level. The distinction in approach provides the prospect of learning across various models, selecting practices for transfer, and developing a more global vision of inclusive Mathematics teaching (Colmenares, 2009).

1.4. Purpose of the Study and Research Questions

The study addresses such gaps by exploring Calculus pedagogy as it currently is, or maybe framed for neurodivergent students in transatlantic contexts. Specifically, this study applies empirical research, policy analysis, and theoretical synthesis to explore the potential to enhance Calculus pedagogy responsive to diverse cognitive styles. In the context of qualitative evaluation of organizational culture, projects, and strategies of a sample of North American and European institutions, the article attempts to speak about neurodiversity-sensitive practice and principles for teaching Calculus. This position takes the neurodiversity to not be something to be fixed but as a design parameter—a source of thoughts that can be drawn upon in order to assist in shaping, filling, and providing Calculus courses.

There are many questions to frame the research. First, what are the expressed pedagogy and curriculum practices employed to teach neurodivergent learners in Calculus courses, and on what tacit assumptions do these practices rest? Second, how do neurodivergent learners understand and interpret their learning environment in respect to instruction in Calculus, and what are their accommodations or constraints that are significant to them? Third, how and to what degree are institutional and national contexts in planning and provision for inclusive teaching of Calculus, and what are trends in the education system? Fourth, what are some of the most effective principles of neurodiversity pedagogy, universal design for learning (UDL), and culturally responsive pedagogy that can be integrated into one strategy for inclusive teaching of Calculus? And finally, how are such a framework co-designed with neurodivergent students so that they are centered, their experience respected, and they are openly empowered to participate in Mathematic communities?

1.5. Contribution and Scope

In addressing these concerns, the article bridge the gap within an emerging literature that crosses the transdisciplinary boundaries of Mathematic teaching, disability studies, neurodiversity activism, and comparative education. It resists the dominant myths of who is "Mathematic gifted" and challenges us to reimagine the Calculus class as epistemically just. That is not merely to reimagine the presentation of information, but to be able to resist curricular norms and values embedded in the choices made—such as the value placed on abstraction over intuition, haste over depth, and solitude over social problem-solving. This inclusive pedagogy of Calculus would attempt to diversify modes of engaging, representing, and expressing; decentre constructions of time; offer multimodal texts; use visual and sensory learning; scaffold conceptual sense; and facilitate multiple Mathematic ways of thinking. The potential value of such work is not only in its responsiveness to one formerly excluded student group, but in its potential to re-make Mathematic education more generally.

If Calculus is pedagogized in a way that it is made accessible to every level of cognitive diversity, it will be more accessible, more meaningful, and more empowering for all the students. Secondly, by calling upon transatlantic scholarship, the article provokes global debate regarding the manner in which the education systems can be made more inclusive without otherwise being lost on account of scholarly excellence. It challenges teachers, principals, policymakers, and curriculum developers beyond compliance to real inclusion—an inclusion that does not wait for the students to persuade them that they are part of the group, but reawakens the space so that all types of thinking can be invited and honored. The article also recognizes that inclusive pedagogy will differ everywhere. What works in one situation will not necessarily translate neatly to another.

Each of institutional resources, teacher training, student expectations, and culture enables and values what is possible. The comparative aspect of the study, then, is not to identify one model but to depict the contingencies and possibilities as different systems head-to-head encounter the same challenges. In syncretic case studies of countries, the article hopes to throw light on tension, creativity, and blindness in hegemonic practice, and cross boundaries and enable conversation. Methodologically, the study employs an intermix of qualitative and policy analysis. Fieldwork includes interviews with Calculus teachers and neurodivergent learners, content analysis of syllabuses and pedagogic materials, and policy analysis of national and institutional inclusive education policy.

Sample includes United States, Canadian, German, and Dutch schools, selected on the basis of linguistic diversity, policy style, and school climate. Participatory approach guides the research, with every level of research design, analysis, and interpretation guided by the recruitment of neurodivergent participants. Collaborative practice to turn the objectification of neurodivergent students around and bring their contribution center stage in educational transformation. Finally, this piece is asking for a pedagogical revolution in Calculus—a pedagogical revolution that involves accepting neurodiversity not as a problem to be solved but as the one that compels us to question what Mathematic teaching might be. As one vision of the capacities and needs of neurodivergent learners, and as a response to the response of the majority of education systems to their needs, the article aims to foster a more democratic and a more imaginative vision of STEM education. Calculus, once an exclusive and dogmatic initiation, could be imagined as a place of inclusion, imagination, and diversity of knowledge. Calculus teaching in the neurodiversity age is not an option—it is an imperative.

2. Method

2.1. Study Design and Context

Qualitative-comparative study design taken from interpretive research whose aim is to determine how Calculus pedagogy needs to be modified to accommodate neurodivergent students in different national and institutional contexts (Castilla Barraza et al., 2025).

The research falls in the theoretical landscape of neurodiversity studies, inclusive education, and comparative education. There were five higher education institutions from North USA and Europe taking part in data collection: two USA-based, one Canadian, one Dutch, and one German. Participants were selected to represent education system, language environment, as well as inclusion policies. Data were collected within eighteen months, January 2023 to June 2024. Participants provided consent accompanied by other measures to maintain anonymity and independence of neurodivergent participants to the study.

2.2. Participants

Participant recruitment was carried out using a combination of purposive and snowball sampling. The main participant group was 38 participants: 20 neurodivergent undergraduate students currently or in the last two years enrolled in at least one Calculus course, and 18 Calculus teaching assistants, professors, and lecturers who have teaching experience with neurodivergent students. Student participant requirements were self-identification as formally diagnosed or self-identified neurodivergent and current or recent enrollment (in the past 24 months) in a university-level Calculus course. We did not need to use formal diagnostic reports to get participants who might not have access to medical assessment but are learning differently. The sample covered a range of neurodiverse profiles such as ADHD, ASD, dyslexia, dyscalculia, and non-specific learning differences.

Recruitment of self-diagnosing participants was justified as a strategy for gaining access to the experience of barriered individuals who were not formally certified, contradicting the medicalized construction of disability; risks of misdiagnosis were contained through the use of intensive screening procedures with an overdependence on observable learning activity and self-identified needs.

Out of the 20 student participants, 13 were clinically diagnosed, and 7 self-identified neurodivergent without clinical verification.

2.3. Instruments and Procedure

Data were collected with three principal instruments: semi-structured interviews, class observation, and document analysis. All instruments were designed to provide complementary data on teaching Calculus to neurodivergent students.

The semi-structured interviews were the central part of the study and gave rich descriptions and meaningful insights. Interviews were done one-on-one, face-to-face or via secure video conferencing software, based on participant convenience and COVID-19 pandemic health regulations. Student participant interviews ranged from 60 to 90 minutes, and instructor interviews ranged from 45 to 75 minutes. Each participant group had interviews done with permission, verbatim transcribed, and checked for accuracy by research assistants. Student interview protocols involved their experience in Calculus class, perceived accommodations and barriers, methods by which they learned, teacher-student relationships, use of accommodations, and what helped or prevented their learning.

Lecture presentation style, use of visual aids, pace, opportunities for interaction, scaffolding strategies, test design, and general accessibility of instructional environments were some areas highlighted by observations. Lessons observed lasted about 90 minutes. To provide more information and to gain first-hand knowledge of pedagogical practice, non-participant classroom observations of 12 undergraduate calculus classes across the five institutions took place. Observation methods were designed upon the principles of universal design for learning and were in the form of field notes and rubrics of assessment. Researchers did not just record teacher behavior, but also documented learner response, for instance, patterns of engagement or disengagement. Researchers did not speak with learners during the class and did everything possible to minimize intrusion. Teachers and students being observed were given advance notice.

Outside the interview and observation, course materials were collected and analyzed, such as syllabi, lecture slides, assignment questions, problem sets, grading rubrics, and accessibility statements. The documents were coded for inclusive design elements, i.e., multiple assessment formats, clear instruction, learning opportunities, scaffolds embedded in materials, and accessible language. Disability teaching, accommodation, and service policy documents at the institution were also referenced to gather information regarding instructional choice in organizational settings.

Data analysis was a multi-step process using grounded theory and thematic analysis. Field notes and interview transcripts were keyed into NVivo 12 qualitative data analysis software first. Initial open coding was conducted to import emergent concepts, patterns, and experiences. This was followed by axial coding, during which equal codes were combined to create broader codes such as "pedagogical flexibility," "barriers to engagement," "institutional constraints," "instructor awareness," and "student agency." Memos were written in the process to document analytical thoughts and link codes to theoretical concepts. Document data were also analyzed at the same time using a deductive coding framework derived from UDL and inclusive teaching theories.

In an attempt to minimize bias and maximize high reliability, coding was conducted independently by two coders and differences agreed by discussion. Inter-coder reliability was also tested at the first stage of coding and was measured as high at a Cohen's kappa of 0.81. Member-checking was also used whereupon findings' summaries were given to a sub-sample of participants to check against the interpretations to ensure that the analysis accurately represented their experiences.

The comparative focus of the research involved similarity and difference examination at and between countries and institutions. It included siting results in policy contexts at the country level, at the institution level, and in faculty development organizations. To take an example, in German and Dutch universities, where inclusion policies are more institutional in intention than they are individualistic in provision, we scrutinized how such frameworks were put into practice. Conversely, North From the USA institutions, and particularly within the U.S., would tend to rely more on models of individual compliance and accommodation to the law. Such contextual differences were not seen as background variables but as forces in operation which inform conceptions of, and responses to, neurodiversity within education practice.

Ethics came first in the research, in particular in communicating with neurodivergent individuals who are potentially at risk of stigmatisation or misrepresentation. The research design prioritized reflexive accountability, participant autonomy, and informed consent. Participants were provided with plain-language summaries of the study justifications and informed about their right to withdraw at any time. Agency was provided to participants during interviews concerning how they wished to describe their neurodivergence, and they were allowed to leave out questions. Anonymity was preserved through the use of pseudonyms, and data identifying individuals were removed from observation notes and transcripts. Data were stored safely on encrypted digital databases accessible by the research team alone.

The participatory dimension of the research was also essential. Four neurodiverse students were employed as peer researchers and assisted in the development of interview protocols, initial coding, and dissemination. Their involvement helped ensure that the research remained grounded in the daily lives of neurodivergent students and did not mirror external or medicalized ideas about how inclusion would be achieved. Peer researchers were remunerated for their time and effort and had regular debriefing sessions throughout the project.

On the question of replicability, the research design offers a good model for subsequent studies to follow. Use of more than one site in more than one country makes contextual responsiveness and cross-case comparison possible. Semi-structured interview schedules, classroom observation schedules, and document analysis rubrics are provided in supplementary materials and can be used by other researchers. Data analysis processes—reciprocal inductive and deductive coding, inter-coder reliability checks, and member validation—are an open and transparent process for qualitative data analysis in a comparative study. In addition to this, the participatory method used here can be considered as an example of how neurodivergent voices are brought into the research process in ethics and epistemologically responsible ways.

3. Results

This transatlantic comparison's findings present a kaleidoscopic picture of practice and experience of Calculus pedagogy with neurodivergent students in diverse institutional and national contexts. From the evidence produced through the performance of semi-structured interviews, classroom teaching observations, and document analysis, there are recurring trends and tensions in the concept of pedagogy, student experience, institutional practice, and cultural assumptions. The results are presented here below in direct answer to the research questions and objectives listed above, with participant voice, realism, and coherence given priority.

3.1. Student Experience and Pedagogical Barriers

In all of the institutions under study, neurodivergent students portrayed Calculus pedagogy as emotionally demanding and cognitively taxing. The most prevalent of these were the abstractions in the content of the courses, lecture pace and brevity, its emphasis on timed tests, and the lack of multimodal presentation of Mathematics concepts. Not that students were intellectually disenfranchised through a lack of will but through pedagogic rigidities incompatible with multiple learning styles and thinking modes. Whereas individual formal accommodations assisted some students to cope with logistical hurdles, such accommodations seldom reached the sub-structural instructional models that designed the hurdles in the first place. Conversely, the minority of Calculus courses constructively founded on inclusive principles—those grounded in Universal Design for Learning—basked in radically improved levels of engagement, comprehension, and retention by neurodivergent students.

One of the most evident trends that was seen was the effect of instructional flexibility. Educators who offered a variety of methods for students to engage with the content (e.g., video lectures, video explanations, scaffolded problem sets, group work, low-stakes quizzes) created environments where students with neurodiversity were safe and included and had greater confidence in their capability. For instance, a Canadian student with ADHD explained how the ability to take an online course where she could do weekly take-home quizzes instead of other timed tests had enabled her to demonstrate what she was learning without shutdown of her intelligence from stress in other classes. In the same vein, an autistic Dutch student used color-coded visual notes and interactive programs to depict chief ideas in order to participate more significantly and autonomously in the content of a Calculus course.

On the contrary, rigid lecture styles—with a single mode of information provision, high-stakes examinations, and minimal feedback—were across-the-board described as exclusionary. In one USA school, four students from different neurodivergent profiles all labelled their Calculus class as an .endurance test.and not a learning experience. The students would typically utilize networks of peer mentors, YouTube clips, or outside tutors in order to deconstruct the material, essentially outsourcing in- and out-of-class learning. This flexibility, while nefarious, mirrors systemic breakdowns to ensure inclusive learning spaces in the institution itself.

Perhaps the most significant finding concerns the disconnect between official accommodations and the immense pedagogical impact. Throughout the five colleges combined, students struggled to access administrative processes in an effort to secure accommodations. There were belated formal diagnoses, inadequate institutional support, and stigma of disclosure encountered by some students. Even where accommodations had been arranged, they were mainly confined to procedural accommodations such as extra time in tests or note-taking. Teachers were able to meet these requirements mostly without alterations to the fundamental means they taught. The structural learning obstacles to Calculus thus remained intact.

Teachers were outraged when they were willing to accept neurodivergent students but were not trained, given time, or institutionally empowered to institute the changes. Teachers in much of the United States and Germany were willing to see inclusion as a task to check off on a regulatory list rather than a possibility to educate. They appreciated that their pedagogical approaches mirrored how they have learned Calculus themselves and were never altered at their foundations to suit other techniques. Professors from the Dutch university, whose professional responsibility required inclusive teaching training, reported heightened confidence and innovativeness in taking first steps towards course alteration. They noted that they experimented with graphical modeling, providing open-source exams, and soliciting student feedback throughout the semester.

Policy-wise, the comparison emphasized the differences between institutions' responses and operationalizations of inclusion. In North USA, there are organizational centers of power in disability services, but their mandate is reactive and document-led. The model is likely to place on students the responsibility to define themselves, to speak up for themselves, and to negotiate an unguaranteed or under-funded model. In Europe overall, and in the Netherlands, inclusive education was viewed more positively as a natural component of the system of institutions. Instead of expecting students to request accommodations, course designs are constructed so that they can be adjusted, and inclusion is viewed as the responsibility of all - faculty, administration, support staff. These variations in the system manifested themselves as variations in the student experience which were quantifiable. Neurodivergent students in the Dutch school experienced fewer obstacles, greater Mathematics self-efficacy, and improved staff relations.

3.2. Politics and Institutional Culture

USA cultural expectations of rigor and achievement were as prevalent in shaping Calculus instruction and engagement. There was a cultural presumption in North From the USA schools, particularly in upscale settings, that rigor equated with difficulty and speed. Teachers also opposed lowering cognitive load or extending timelines in case the academic threshold was lowered. This assumption was also likely to lead to teaching practices that inadvertently disadvantaged neurodivergent students, perhaps taking longer or engaging in another activity to attempt demonstration of understanding. Rigor in the German and Dutch schools was more related to depth of knowledge and conceptual clarity. More likely to paraphrase examinations to provide for several ways of demonstrating, e.g., project work, oral examination, and portfolios. Examinations were where possibility and exclusion were the issue.

Timed examinations were cited as the most stressful and the least inclusive component of the Calculus course in every institution. It was the bulk of the neurodivergent students who encountered mental blocks, senses overwhelmed, or executive function breakdown on timed tests despite having command of the material. The instructors became informed of this challenge and adjusted by providing take-home tests, group problem sets, or iterative assignments. Adjustments accompanied augmented learning for the neurodivergent students as well as the entire class. Innovations of this type were rule and not exception. The most unexpected was perhaps the level of self-advocacy and peer support among neurodiverse students.

Students described the establishment of ad hoc study groups, the sharing of resources, and peer mentoring where institutional provision had not existed. It is testimony to the enterprise and resilience of neurodiverse learners but also a product of failure on the part of systems. Institutions without systematic, inclusive systems of support had largely left inclusion in the hands of their students. Institutions that encouraged peer mentoring programs, pedagogical fellowships for diversity, and student-faculty forums, however, instituted the type of environment in which neurodivergent students would thrive.

3.3. Document analysis validated the findings

Course syllabi for North From the USA institution courses barely included neurodiversity statements or special accessibility practices outside normal accommodation provisions. Lecture notes and problem sets employed dense notation to the extent of omitting visual scaffolding, whereas institution syllabi from the Euroregion—specifically the Dutch—made explicit assurances of accessibility, asked learners to reveal their learning style, and offered illustrated flexible routes to examination. Instructional material used in these settings applied step-by-step annotating, diagrams, animation, and examples within the context of a variety of application domains, and all were used to make the material more accessible.

3.4. Co-Design

Finally, co-design with peer researchers enriched the findings. Neurodiverse student-researchers emphasized Calculus courses should dispense with deficit thinking. They called for pedagogical pluralism—the acknowledgement there are some good ways of teaching and learning Calculus. They provided comment that informed interpretation of results, indicating particularly how slight variations in course design (e.g., introduction of advance organizers, coloring, decomposition of problems into more fine-grained pieces) may disproportionately impact neurodivergent learners. They further emphasized the affective dimensions of learning—trust, respect, and recognition—historically not included in STEM education studies.

4. Discussion

Summary of findings of the present study replicates and confirms some lines of earlier work in inclusive education, language and Mathematics instruction, and neurodiversity. It has previously been proven that students with neurodiversity, in this case, students with autism spectrum disorder or ADHD, cannot thrive in sequenced school environments with focus on norm-referenced testing and lecture instruction (Alsina & Coronata, 2014). This current research reaffirms the above but framed in the context of Calculus instruction and how the marriage of symbolic abstraction, very high cognitive requirements, and method of instruction to teach it represents a unique set of challenges to neurodivergent students. This provides the rationalization for prior observations By Astudillo (2005) wherein it was claimed that higher Mathematics are inadvertently structured in terms of a form of cognitive functioning.

Against such articles inviting neurodivergent students as being born disabled, this book places fact to assumptions of Bishop (2000) and others that neurodivergent individuals are usually born with dormant or latent Mathematics ability, especially if their talent is adapted in lessons. The learners in this research indicated that they were assisted by visual modeling, scaffolded thought, and adaptive assessment—practices that are evidence-based Universal Design for Learning. The inclusion of inclusive design instruction and greater participation in this case is consonant with research by Colmenares (2009), whose work showed that more inclusive classrooms would be better for all students, not only students who do have official diagnoses.

Other than this, comparative education studies confirm the benefits of institutional culture and national policy in shaping implementation of inclusion, and systemic literature inscribes systemic design as a more vital imperative than remediation at the individual level. The Dutch policy, from faculty development to curriculum development, is the reverse of the North From the accommodation dependence by law compliance. This aligns with Alsina (2019) contention that reactive accommodations are less likely to destabilize ableist assumptions in education systems.

Aspects of the staff resistance to change experimented with modes of assessment also aligns with Giménez et al. (2007) findings that staff will be more likely to associate rigor and convention, and not evidence-based teaching. This study is a further extension of such criticism in that it illustrates how such mind sets facilitate a Calculus pattern of exclusion, most starkly when testing fails to yield variability in executive functioning, sensory processing, or information storage. Success with alternative testing in some of the classes observed, however, illustrates the constructive potential of constructivist Mathematics teaching to be challenging but inclusive (Rojas-Ferreira, 2016).

This research adds to this emerging literature on affect and emotion in STEM learning. These neurodiverse students here explained to us over and over that they must be heard, seen, and helped—such are valued feelings in typical STEM instruction. This agrees with Alsina (2019), who found that positive relationships and culturally responsive teaching are essential for marginal learners in science and Mathematics classrooms (Rodríguez Gallegos, 2017).

Lastly, that co-researcher involvement in this study took place and that the co-researchers were neurodivergent students is an empowering testament to disability studies' assertions to shift from research about neurodivergent students to research with them. The effective application of the co-design strategy testifies to the possibility that co-design methods can potentially provide more equitable and inclusive accounts of educational facilitations and constraints. It also flips traditional research power dynamics by recognizing experiential knowing as legitimate data and analysis (Soto, 2008).

5. Conclusion

The purpose of this research was to investigate affordances and limitations of current Calculus pedagogy for neurodivergent students in a transatlantic context, from pedagogical practice to institutional policy, and learner experience across five North From the USA and European institutions. The study comes forth with a recurring, cross-cutting problem: neurodivergent students are in facto excluded from typical Calculus teaching at the college level—not as a function of intrinsic cognitive disabilities nor as a result of instruction content but as a result of cognition-slow designs, pedagogies, and cultural models that are incompatible with diversity.

The first significant finding is that learning Calculus is a field of exclusion for neurodivergent students not because of Mathematics incompetence, but because of pedagogic inflexibility, timed examinations, and uniform teaching methods which are inadequate to accommodate their needs. In the institutions covered in the survey, the same list of barriers was uniformly applied from sensory overload during classes to executive function deficits under high-stakes testing. Even with one-to-one adjustments, all these problems continued. The commonality here is that typical pedagogies of Calculus pedagogy and most neurodivergent learners' ideal ways of learning cannot coexist. These results make deficit assumptions harder and less hegemonic, and they unmake hegemonic mainstream pedagogical norms.

A second implication is that inclusion pedagogy—i.e., teaching practices grounded in the Universal Design for Learning principles—has real potential to boost engagement and achievement among neurodivergent students to an exceptionally high degree. During the study, when instructors applied practices like multimodal instruction, flexible administration of tests, instructionally scaffolded, and open course organization, neurodivergent students reported feeling more understood, less stressed, and more motivated. These strategies neither sacrificed academic content nor stretched the epistemological scaffolding on which students learned Mathematics content. This finding is consistent with previous UDL studies but is focused on postsecondary Calculus, a field of Mathematics which, since it emerged in the late nineteenth century has been identified as most resistant to remodeling practice.

The third key finding has implications for institutional design and national education cultures. What the study found was extremely deep differences between institutions that had adopted the strategy of responding through law compliance and people accommodation as opposed to proactive and design-led approaches on accessibility. Dutch and, to some extent, German institutions were further along an inclusive values continuum at the system level. North From the USA schools, on the other hand, appeared to be in a culture of medicine and bureaucracy where responsibility for advocacy rested in the student self. Such structural dispositions therefore touched on everything from the disposition of faculty to the construction of syllabi and assessment policy. This would mean that inclusion is not possible on an ad hoc basis by acts of good will but rather needs to become ingrained in the fabric of policy and institutional practice.

A fourth conclusion is that teachers hold an intractably contradictory place in the argument for inclusion. In a certain measure, the faculty actually wanted to serve neurodivergent students but were also often complaining that they were uninformed, unsupported, or unprepared regarding inclusive pedagogy. This implies that there is institutional demand for faculty development served by training, reward systems identifying inclusive pedagogy, and communities of practice. Also, the breakthrough demands inclusion not to be assumed as an extra accommodation or a burden but as a sign of pedagogic excellence that advantages all students.

Fifth, the research presents the difference between accommodations in law and learning in life. Accommodations in form such as additional time and note taking can be used to reduce some of the barriers but will probably not always address more deep-seated pedagogical mismatches. Student-identified accommodations addressed symptoms rather than causes—offering logistical solutions without challenging epistemological and instructional assumptions underpinning Calculus instruction. This conclusion is substantiated by attacks from the field of disability studies and indicates a need for systemic redesign rather than individual remediation.

Sixth, the research identifies the emotional and affective aspects of learning Mathematics. Neurodiverse students were never not discussing how stress, anxiety, self-doubt, and stigma accrued to their learning capability for Calculus. These affective responses were not secondary effects but learning obstructions in their own right. In entering the emotional labor of charting unenterable landscapes of learning, teachers and policymakers have to explore the whole terrain of inclusion. This translates into classroom design that makes students safe, valued, and empowered, rather than accommodated.

Seventh, joint research with the neurodivergent students as co-researchers was needed to allow context-rich and situated outcomes. Their expertise guided not merely the development of research instruments but also interpretation of the findings. It was a deliberate approach in consonance with the principle that people most affected by educational practice and policy must be involved in their creation. It is likewise an exercise of the significance and use of co-creation in educational study, in particular in addressing pervasive problems such as translating inclusion and neurodiversity into practice.

Eight, what the study reveals is that inclusive pedagogy in Calculus courses is not just feasible but to everyone's advantage. Instructors who tested out on inclusive strategies found enhanced classroom climates, heightened student participation, and improved learning results across the board—not only for neurodivergent students. That is to say that what too commonly is occurring under the banner of "accommodation" is superior teaching and learning in the vast majority of instances. By placing neurodivergent students at the forefront of the design process, educators can develop practices beneficial to all students and transcend the well-known norm-difference binary.

Ninth, the study identifies some of the most promising sites of leverage for systems change. They are inclusive pedagogy development courses for faculty, curriculum redesign projects with planned flexibility, reform of assessment ending high-stakes testing, and policy settings that support innovation and collaboration. Change has to occur at more than one level—department, institution, classroom, national policy. Piecemeal will not be enough. What we will need is culture change in math education for constructing excellence.

Tenth, the research takes into account the necessity of additional study and data collection. With greater interest in inclusion, limited empirical examination of Calculus and neurodiversity has been conducted. Additional study is needed to examine the long-term effects of inclusive interventions, the interaction of neurodivergence with race, gender, and socio-economic status, and whether new technology can be employed to facilitate access to learning. All subsequent activity will also need to take account of the process of institutional change—charting how to break down barriers and put good practice in place at scale.

Lastly, this research calls for a fundamental rethink of university teaching of Calculus. It calls for an end to accommodation and a transformation, compliance and creativity, and marginalisation and inclusion. Neurodivergent students are not anomalies—rather, they are outstanding members of our school communities whose differences and talents can challenge us to more compassionate, improved, and fairer schools. The study findings challenge us to move past assumptions of surface-level accessibility and to unleash the full power of cognitive diversity as an engine of innovation, a source of resilience, and an engine of academic achievement.

Calculus—commonly viewed as a gateway course—is no more an impenetrable barrier to access and achievement. Thoughtfully crafted, with collaboration and equity focus, it can be an open door of promise for everyone. This vision is not pie in the sky but achievable.

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