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Fallibilist analysis of epistemic assumptions underlying the AHS-curriculum

Contributions of fallibilist epistemology to competence-oriented pedagogy

verfasst von | submitted by

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Education remains disappointing, and […] will continue to disappoint unless we can make an assault on the presuppositions which underlie it, and the content of courses and syllabuses which grow from these assumptions. If education is to offer any help towards solving the problems of individuals or of society, it must do so directly by helping individuals to formulate problems and to propose and test solutions. It cannot do so by its present practice of offering (in Popper's striking phrase) 'unwanted answers to unasked questions'. (Burgess 1986, p.67)

Abstract

English Version

National curricula are documents that specify the learning goals of national educational policy. They are inevitably shaped by epistemological assumptions, which can be informed by a variety of perspectives, such as rationalism, empiricism, relativism, fallibilism, or a mixture of these approaches to knowledge and learning. As an educator, I am interested in exploring the epistemological assumptions underlying the Austrian curricula, as these documents shape educational practices and require obligatory implementation by educational institutions. The purpose of this research project is, first, to analyze the epistemological assumptions present in the curriculum, with a particular focus on the dominant educational paradigm—competence-oriented pedagogy (kompetenzorientierte Pädagogik). The second part of the research project outlines relevant contributions of fallibilist ideas to epistemology and discusses whether the curriculum's epistemology might be enhanced by integrating specific fallibilist concepts and theories. Finally, the third part outlines what fallibilist principles in didactics might entail and explores the educational practices that could follow from such principles.

German Version

Nationale Lehrpläne sind Dokumente, die die Lernziele der nationalen Bildungspolitik festlegen. Sie sind unvermeidlich von epistemologischen Annahmen geprägt, die von einer Vielzahl an Perspektiven beeinflusst sein können, wie Rationalismus, Empirismus, Relativismus, Fallibilismus oder einer Mischung dieser theoretischen Zugänge zu Wissen und Lernen. Als Pädagoge interessiere ich mich dafür, die epistemologischen Annahmen, die den österreichischen Lehrplänen zugrunde liegen, zu untersuchen, da diese Dokumente die Bildungspraxis prägen und die verpflichtende Umsetzung durch Bildungsinstitutionen erfordern. Ziel dieses Forschungsprojekts ist es zunächst, die epistemologischen Annahmen im Lehrplan zu analysieren, wobei ein besonderer Schwerpunkt auf dem dominierenden Bildungsparadigma – der kompetenzorientierten Pädagogik – liegt. Der zweite Teil des Forschungsprojekts skizziert relevante Beiträge fallibilistischer Ideen zur Erkenntnistheorie und erörtert, ob die im Lehrplan eingebettete Epistemologie durch die Integration spezifischer fallibilistischer Konzepte und Theorien verbessert werden kann. Abschließend skizziert der dritte Teil, wie fallibilistische Prinzipien in der Didaktik aussehen könnten, und untersucht, welche Bildungspraktiken aus solchen Prinzipien hervorgehen können.

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List of Abbreviations

AbW – Auf der Suche nach einer besseren Welt (1984 [1999])

ALiP – All Life is Problem Solving (1994 [2007])

CaR – Conjectures and Refutations (1963 [2002])

LSD – The Logic of Scientific Discovery (1935 [2002])

MoF – The Myth of the Framework (1994 [1996])

OK – Objective Knowledge (1973 [1994])

OS – The Open Society and Its Enemies (1945 [2011])

FST – Facts, Standards, and Truth: A further critique of relativism (1961 [2011])

RaS – Realism and the Aim of Science (1956 [1983])

UQ – Unended Quest (1974 [1976])

Acknowledgments

I am deeply grateful to my supervisor, Mag. Dr. Christian Damböck, for his invaluable guidance and constructive feedback throughout this research project. My sincere thanks also go to Dr. David Deutsch, whose work on epistemology inspired this thesis and who has also generously given me the opportunity to discuss his ideas in person. Most importantly, this thesis is dedicated to my parents, whose wisdom, love, and support have made this work possible in more ways than they might imagine. My gratitude also extends to all members of my family, and especially to my sisters and grandparents, who have taught me so much over the years. Lastly, I want to acknowledge my students and colleagues, who have continuously challenged me to think deeply and creatively about learning and teaching.

Note on the Use of Translations

This research focuses on the Austrian educational system and the pedagogical discourse within German-speaking contexts. To make my thesis more accessible to non-German speakers, I have chosen to use English as the primary language for this work. However, as of the date of writing, several key sources, including the Austrian AHS curriculum, are available only in German. In such cases, I have provided my own translations. For German terms with no direct English equivalents, I have included the original German term in brackets alongside my translation.

Introduction

Since the beginning of the 21st century, competence-oriented pedagogy has gradually become the dominant pedagogical paradigm in the Austrian educational system. It is embedded in legislation that organizes educational institutions, including curricula and schools, informs lesson materials, and prescribes a didactic approach for teachers. The starting point of this research project is the straightforward fallibilist assumption that all theories, including the competence-oriented paradigm, can be improved. Every educational paradigm—whether it be the largely abandoned behaviorist approach or the current focus on competence—is interdisciplinary and thereby underpinned by a range of theories. These theories span fields such as psychology, politics, ethics, and, importantly, epistemology.

The central focus of this thesis is the epistemology underlying the AHS curriculum. This focus is significant because the epistemological assumptions in the curriculum exert substantial influence on the educational system. This influence is evident in the extent to which actors and institutions within the system—such as policymakers, educators, administrators, students, and legal guardians—are, to varying degrees, bound by curricular specifications. Therefore, this research project seeks to understand the epistemology of competence-oriented pedagogy as formulated in the AHS curriculum. Additionally, this project aims to critique certain curricular assumptions regarding knowledge, learning, and teaching and to propose improvements drawn from the strict fallibilist perspectives of Karl Popper’s philosophy and its modern adaptation by physicist David Deutsch.

Methodology

The motivation for conducting this research project stems partly from my experiences as a teacher in training and partly from my fascination with the philosophy of knowledge and learning, a passion that has deepened throughout my university studies. Through my involvement in various educational institutions, whether as a student or teacher, I have increasingly come to suspect that the teaching practices in Austrian educational institutions today fall short of effectively serving both learners and educators. It seems to me that the theories of knowledge underpinning many didactic approaches can be improved, which could, in principle, lead to significant advancements in how knowledge, learning, and teaching are conceptualized and practiced.

I further suspect that ideas formulated by Karl Popper hold critical potential for enhancing current theories of knowledge. My fascination with Popperian philosophy was sparked by my exposure to the ideas of physicist David Deutsch. His ability to present simple sounding yet profoundly insightful ideas has struck me as exceptional among modern thinkers. His work has fundamentally reshaped my understanding of the theory of knowledge and, consequently, my conception of learning and teaching. Moreover, in June 2024, I had the privilege of interviewing David Deutsch about his views on broad aspects of education, which served as a major inspiration for writing this thesis.

This research project is primarily directed at teachers and members of educational institutions. It is intended as a contribution to the field of research focused on understanding and improving aspects of the educational system, specifically the epistemology underlying the curriculum and the didactics that follow from it. The project may be classified as theoretical research, aiming to provide a framework within which the practical implications of modifications to competence-oriented pedagogy might be considered. The hope is that this research offers valuable insights and lessons for enhancing educational institutions.

Epistemology Informs Pedagogy

Every educational endeavor is permeated by an epistemological theory, whether it is made explicit or remains implicit. The considerations and decisions around a specific approach to learning or teaching are inevitably informed by theories about knowledge and its growth. For this research project, the concept of epistemology—the theory of knowledge—will encompass learning, understood as the growth of knowledge, and teaching, conceptualized as the process of assisting people in creating knowledge. Because educational theories, both pedagogical and didactic, involve frameworks that specify what is to be learned, how it is to be taught, and which assessment methods are used, they inevitably rely upon a substantial support structure of epistemological assumptions. This project will analyze and critique the epistemological assumptions of competence-oriented pedagogy from a philosophical perspective that may hold the potential to improve several of its key features.

Research Questions

The research project addresses three main questions:

1) How does the AHS curriculum conceptualize knowledge, teaching, and learning?
2) What contributions can critical epistemology, as articulated by Karl Popper, and Neo-Popperian philosophy, as represented by David Deutsch, offer to the current understanding of knowledge, teaching, and learning in the Austrian educational context?
3) How can a fallibilist approach to didactics be conceptualized, and what are the broader implications of adopting fallibilist principles within the Austrian educational system?

Philosophical Framework

The epistemological perspective adopted for this research project can be described as Neo-Popperian fallibilism. This approach primarily draws on the epistemology of the Austro-British philosopher Karl Popper and subsequent theories that are still informed by Popperian epistemology. Notably, this includes a modernized and expanded version of Popperian fallibilism as articulated by British-Israeli physicist and philosopher David Deutsch, whose contributions to Popper's philosophy will be referenced throughout this work. Additionally, some educational theorists have developed pedagogical

theories based on Popperian epistemology, several of which inform this research project.

To avoid terminological confusion, "Popperian fallibilism" is used here interchangeably with “critical rationalism” and “critical epistemology.” The term "Neo-Popperianism" refers specifically to the philosophical approach of David Deutsch and his extensions to Popper’s philosophy. As used here, Neo-Popperianism encompasses Popper’s epistemology along with its augmentation by Deutsch. An important feature of Popperian philosophy is its reluctance to define terms, which stands in stark contrast to some analytic philosophy traditions. For Popper, definitions serve primarily as abbreviations rather than attempts to describe concepts exhaustively; he was firmly opposed to debates about the meaning of words. In Popperian theory, terms need only be as precise as the problem at hand requires, which leads to the second key methodological feature of Popperian philosophy: problem orientation.

From a Popperian perspective, philosophy, science, and most human pursuits are quests to solve problems. In philosophy and science, the aim is to explain the world, from which solutions to practical issues can be derived. Popper often begins his discussions with a problem and its associated questions, demonstrates why existing answers to these questions fall short, and then reassesses and refines the question before proposing his solution. This method will be reflected in this thesis.

Finally, it must be noted that this work adopts a Neo-Popperian perspective throughout. Providing a comprehensive critique of this philosophical framework lies beyond the scope of this research project. However, it is important to acknowledge that this perspective has been the subject of extensive criticism from diverse philosophical schools of thought, including members of the Vienna Circle and the Frankfurt School.

Structure of the Research Project and Analytic Procedures

Based on the three research questions, this project follows a tripartite structure. Each of the three parts addresses a central problem and is organized into segments, which are further subdivided into sections.

The first part of this research project aims to understand the epistemology of competence-oriented pedagogy as outlined in the Austrian AHS curriculum. To achieve this, it analyzes the curriculum's underlying epistemological assumptions regarding knowledge, teaching, and learning. Sections 1-3 of the 2023 version of the AHS curriculum, which contain much of its epistemological framework, along with relevant documents from the Ministry of Education, serve as the primary sources for this analysis. The section begins by examining the role of curricula in the Austrian education system, followed by a brief overview of the AHS as an educational institution, given the central role of its curriculum in this analysis. The structure of the AHS curriculum is then reviewed, concluding with an in-depth look at competence orientation as presented in the curriculum.

The second part addresses how Neo-Popperian theories can contribute to enhancing the educational theories informing the AHS curriculum. This section begins with an overview of Popperian philosophy, followed by an exploration of Neo-Popperian concepts that seem to offer valuable insights for critiquing and refining the epistemology of competence orientation, particularly in relation to knowledge and learning. Next, Popperian educational theories are discussed and contrasted with other influential educational theories. In the final section, the curriculum’s epistemology is critically analyzed from a Neo-Popperian perspective, with specific suggestions for improvement.

The third and final part of this research aims to outline how Popperian teaching principles might be conceptualized within the Austrian educational context. This section begins by briefly reviewing the curriculum’s requirements for competence-oriented teaching and then considers alternative approaches to competence orientation, such as a shift toward a problem-based paradigm. Neo-Popperian didactic principles are then discussed, with a focus on teaching methodologies. Finally, Popper’s concept of the open society and the issue of tradition are examined in relation to a didactic approach informed by Popperian learning theory.

Part 1: Analysis of Epistemological Assumptions Embedded in the AHS Curriculum with Special Focus on Competence-Oriented Pedagogy

This part of the project serves as the starting point for understanding the structure of the curriculum and the epistemological assumptions underlying it, particularly those concerning knowledge, teaching, and learning. It begins with an examination of the function of curricula within the Austrian educational context, followed by an overview of the structure of the AHS curriculum. Subsequently, the didactic framework of the AHS curriculum, focusing on Sections 1-3, will be presented. In conclusion, the educational paradigm of competence orientation will be discussed to provide context and direction for subsequent parts of the research project.

1.1. The Role of the Curriculum in National Educational Institutions

For conducting an analysis of the epistemological assumptions in the AHS curriculum, a viable starting point is an examination of the function of curricula within the Austrian school system, which is addressed in this segment of the research project. Generally, curricula are devised by the Austrian Federal Ministry of Education, Science and Research (BMBWF). The ministry states:

> For teachers, curricula form the basis for their independent, responsible teaching and educational work. It is teachers' duty to help individual pupils achieve the objectives specified in the curriculum through suitable lesson planning and design. The curricula provide pupils and legal guardians with guidance on the knowledge and skills that pupils should have at their disposal at the end of a school year. Furthermore, they provide a point of reference for the development of teaching materials and for teachers' continuing education and training. The Federal Ministry of Education, Science and Research devises the curricula. (BMBWF, 2020)

This statement highlights one overarching function of the curriculum with three key aspects that are important when considering its role in the Austrian educational system. The primary function of the curriculum is prescriptive. Regardless of school type, the curriculum specifies educational goals, both in terms of the teaching material and the didactic approach by which the material is to be taught. This is evident in the statement that "it is the teacher's duty to help individual pupils achieve the objectives specified in the curriculum through suitable lesson planning and design." Here, suitable must be understood as referring to the educational objectives outlined in the curriculum for each subject.

The second key aspect of the curriculum's normative function is its legally binding nature. In other words, teachers are legally bound to fulfill the educational goals specified by the curriculum. This establishes the fact that educators, from the perspective of the curriculum, are not intended to work independently of the curriculum. Thus, educators are autonomous in their teaching to the extent that the curricular requirements are not disregarded or contradicted.

The third aspect of the curriculum's function is its role as a guide and reference point for teachers in planning their lessons. It serves as a foundation for pre-service teachers to design and justify their didactic materials and provides a framework for in-service teachers to align their teaching practices with the curriculum's objectives.

Regarding the content of the curriculum, its structural requirements are defined by the School Organization Act (*Schulorganisationsgesetz*, SchOG), which mandates the inclusion of five key aspects. First, the general educational goals must be specified. Second, the educational goals of each subject, along with the corresponding didactic principles, must be clearly outlined. Third, the curriculum must detail the teaching material for each subject. Fourth, it is required to account for the distribution of teaching material across individual grades when necessary to achieve the specified educational goals (*Schulorganisationsgesetz*, 2024, §6, Art. 2).

1.2. AHS as an Educational Institution in the Austrian Education System

This research project focuses on the epistemology of the AHS curriculum. Therefore, a brief survey of the main aspects of this school type is presented in this segment.

The abbreviation "AHS" stands for *allgemeinbildende höhere Schule*, which can be translated as "academic secondary school." The AHS is a central educational institution in Austria, encompassing four years of lower secondary education and four years of upper secondary education. According to the School Organization Act (*Schulorganisationsgesetz*, SchOG, §36, 2024), the AHS is divided into three main forms. The first is the humanistic *Gymnasium*, which emphasizes social sciences, languages, and what is often referred to as the humanities in American educational discourse. The second form is the science-oriented *Realgymnasium*, which focuses on STEM fields and other sciences. Lastly, there is the economically oriented *Wirtschaftskundliches Realgymnasium*, specializing in vocational training.

Admission requirements for entering an AHS are mandated by the SchOG (§40, 2024). The typical age range for students attending the AHS is from 10 to 18 years. In 2019, there were 213,046 students enrolled in this type of school, making it one of the most popular secondary education options in Austria (BMBWF, 2021, p. 8).

The role of the AHS within the Austrian education system is specified by the SchOG as twofold. First, the AHS aims to provide students with both a "general" and "in-depth" education. Second, it is tasked with preparing students for tertiary education (SchOG, 2024, §34). At the upper secondary level, this role is underscored by the leaving exam, the *Matura*, which functions as both a gatekeeping and selective mechanism for university admissions.

1.3. Analysis of the Epistemology in the Curriculum

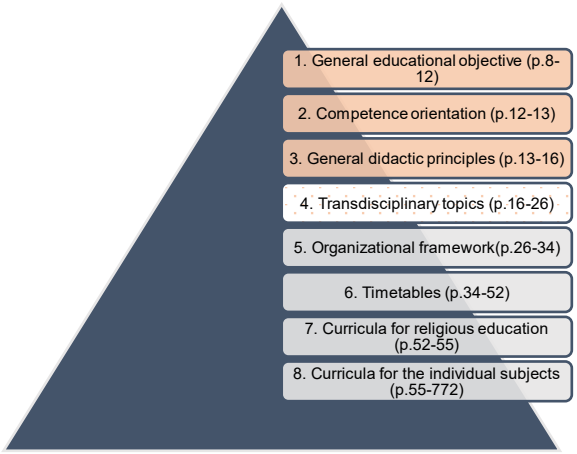
This segment of the research project aims to explicate the epistemological assumptions in the general part of the curriculum. To achieve this, a brief overview of the curricular structure will first be provided, without delving into specific content points. This overview is intended to facilitate navigation within the document and clarify the purposes of each section, some of which are subdivided into multiple parts. Following this structural discussion, the first three sections of the curriculum will serve as the focal point for analyzing its conception of knowledge, learning, and teaching. Particular emphasis will be placed on the concept of competence orientation, which represents a central tenet of the curriculum. Finally, key insights and questions will be summarized and discussed to frame the findings and provide direction for subsequent parts of the research project.

1.3.1 The Structure of the AHS Curriculum

In its 2023 version, the AHS curriculum is structured into eight main sections. The first three sections establish a general framework for didactic practice, which is subsequently applied to the subject-specific curricula. Since the epistemological content of the curriculum is primarily embedded in this didactic framework, these first three sections form the focus of the analysis. The following is a brief survey of the structure of the eight sections of the AHS curriculum, with particular emphasis on the first two sections.

Figure 1

The Pyramidal structure of the curriculum



Section 1

The first section of the AHS curriculum, titled "General Educational Objective," is structured into five parts (Austrian AHS Curriculum, 2023, pp. 8–12). The first part outlines the function and structure of the curriculum, stating:

> The general educational goal, together with the expectations of the lesson design, the explanations on competence orientation and the general didactic principles as well as the organizational framework, including the timetables, form the basis for the implementation of the curriculum. Furthermore, a differentiation is made between subject-specific, cross-curricular, and interdisciplinary skills along overarching themes. (Austrian AHS Curriculum, 2023, p. 8)

This highlights that the Austrian AHS curriculum is designed in a top-down manner. Conceptually, the curriculum can be imagined as a pyramidal hierarchy, where the general and foundational aspects at the top establish the conditions for the lower levels. In this model, the first three sections set the didactic framework, which underpins the organizational specifications and expectations for teaching specific subjects. Positioned in the middle of this hierarchy, the section on "transdisciplinary topics" specifies mandatory themes deemed to represent "essential social aspects" (p. 12) and must be integrated into subject teaching. However, it is noteworthy that the inclusion of these transdisciplinary topics is not mandatory at the upper secondary level.

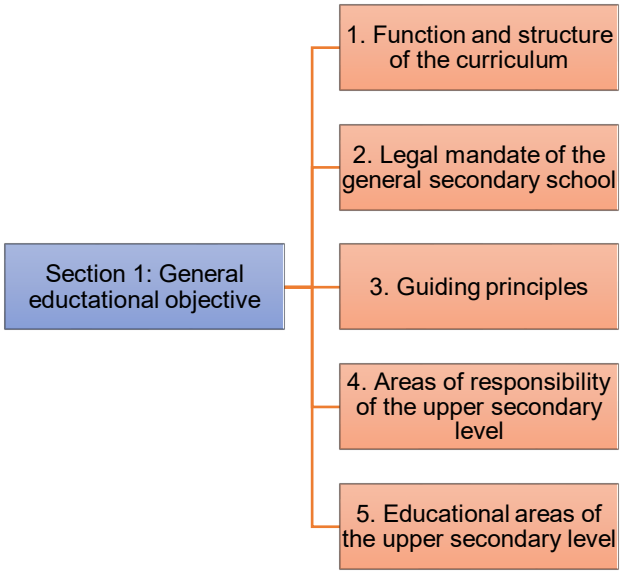
The second part of the first section, titled "Legal Mandate of the General Secondary School" (pp. 8–9), specifies the educational aims of the AHS in alignment with §2 of the SchOG (2024). The third part, "Guiding Principles" (pp. 9–10), outlines the curriculum's vision for education, which is aligned with the 4K model of 21st-century skills. It also commits to "empowering young people to play an active role in overcoming societal, social, economic, and ecological challenges" (p. 9) while emphasizing the social dimensions of schools as spaces for moral and social development.

The fourth part, "Areas of Responsibility of the Upper Secondary Level" (p. 10), highlights the dual objectives of knowledge acquisition and competence development as key priorities for the upper secondary level. It also describes the interplay between competence and knowledge in various dimensions, such as the development of social competences.

The fifth and final part of the first section, "Educational Areas of the Upper Secondary Level" (pp. 10–12), focuses on five educational areas considered essential to general education: "language and communication," "people and society," "nature and technology," "creativity and creation," and "health and fitness" (p. 10). This section also states that these educational areas, together with the objectives outlined in the "Tasks of the Upper Secondary" and "Guiding Principles," form the reference framework for aligning subject contributions with the overall educational goals of the school (p. 10). The integration of these three parts establishes the foundation for the educational content that is both taught and learned.

Figure 2

Section 1 of the curriculum



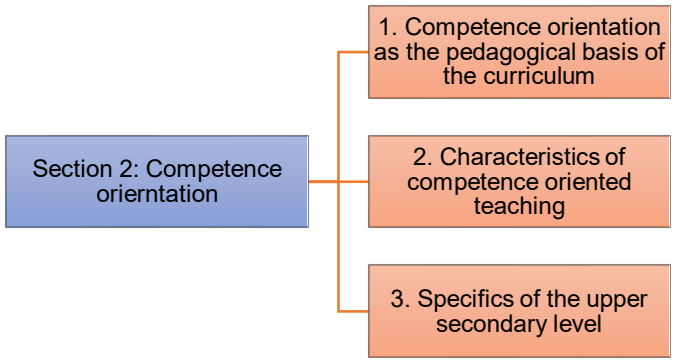
Section 2

The second section of the curriculum, titled *Competence Orientation* (Austrian AHS Curriculum, 2023, pp. 12–13), is divided into three parts and provides insight into the curriculum's central educational paradigm. The first part, *Competence Orientation as the Pedagogical Basis of the Curriculum*, explains how the concept of competence is to be understood and distinguishes between various types of competences. Furthermore, it asserts that competence orientation is supported by what the curriculum refers to as "reflective basic education" (p.12.)

The second part, *Characteristics of Competence-Oriented Teaching* (p. 13), outlines the requirements that competence orientation imposes on the conception of learning and teaching. Finally, the third part, *Specifics of the Upper Secondary Level*, clarifies that, unlike the lower secondary level, precise formulations of competences as expected learning outcomes are not provided for the upper secondary level. Instead, this part underscores the mandatory preparatory role of lessons for the standardized *Matura* at the upper secondary level, aligning with the AHS's goal of preparing students for tertiary education.

Figure 3

Section 2 of the curriculum



Sections 3–4

The third section, *General Didactic Principles* (Austrian AHS Curriculum, 2023, pp. 13–16), outlines and elaborates on eight didactic statements that, according to the curriculum, must be observed to achieve "successful, competence-oriented teaching" (p. 13). These principles serve as a foundation for guiding teaching practices across subjects.

The fourth section, *Transdisciplinary Topics* (Austrian AHS Curriculum, 2023, pp. 16–26), lists thirteen topics selected "on the basis of their topicality and their expected significance for pupils' future lives" (p. 16). These topics are intended for integration into teaching practices and emphasize the inclusion of "ecological, economic, and social dimensions" under the overarching principle that "education for sustainable development must be seen as a general concern and guiding principle throughout the entire school" (p. 16). Structurally, the transdisciplinary topics follow a uniform format: societal relevance is discussed first, followed by the formulation of competence goals, and finally, the identification of subjects that incorporate these topics.

Sections 5–6

The fifth section, *Organizational Framework* (Austrian AHS Curriculum, 2023, pp. 26–34), is divided into ten parts. It addresses key aspects such as school autonomy, including individual subject focus areas, school leadership, and the organization of teaching and subjects (p. 27). Additionally, it outlines areas of autonomy for students within school subjects. The section also specifies grade-specific requirements for assessments and discusses options for daycare services. The sixth section, *Timetables* (pp. 34–52), details the allocation of weekly lessons per subject and includes specifications unique to the AHS school form. It also differentiates between the requirements for lower and upper secondary levels.

Sections 7–8

The seventh and eighth sections, respectively titled *Curricula for Religious Education* and *Curricula for Individual Subjects* (Austrian AHS Curriculum, 2023, pp. 52–772), together constitute approximately 93% of the document and share a similar structure. According to the first section of the curriculum, the primary structural elements for each subject include educational and teaching tasks, didactic principles, subject-specific competence models, and central subject concepts with corresponding competence descriptions.

1.3.2. Section 1: General Educational Objective

The first section, *General Educational Objective*, primarily states the purpose and goals of an AHS education, already containing numerous hints of epistemological assumptions embedded in the curriculum.

Goals and Purposes of the Educational Process

First and foremost, the curriculum emphasizes the individuality of students and the importance of their lived realities, aiming to "take into account the personal realities of the students" (Austrian AHS Curriculum, 2023, p. 12). This intention is further elaborated in the second section of the curriculum, aligned with § 2 SchOG (2024), which defines the purposes of the AHS. It states that the AHS "should promote the individuality of students in accordance with ethical values so that students are prepared for life and their future careers and acquire the skills to learn independently" (p. 8f). Additionally, it aims to "cultivate openness towards the political and ideological (*weltanschauliches*) thinking of others and enable young people to participate in the economic and cultural life of Austria, Europe, and the world" (p. 9).

The curriculum further identifies a dual purpose: preparing students for tertiary education while providing a "deeper general education" (Austrian AHS Curriculum, 2023, p. 9). Regarding general education, the curriculum highlights fostering autonomous thinking and states that the school "must also contribute to the education of young people by supporting them in the acquisition of knowledge, the development of skills and competences, and conveying values" (p. 9).

In part four, *Areas of Responsibility for the Upper Secondary Level*, knowledge acquisition and competence development are specified as main responsibilities. The curriculum notes:

> "One of the school's central tasks in developing subject-related skills is to impart well-founded knowledge. In the sense of lifelong learning, pupils should be enabled and encouraged to acquire knowledge independently and actively, but also to engage in a critical examination of the available knowledge" (Austrian AHS Curriculum, 2023, p. 10).

Additionally, students are encouraged to "deal with problems in an age-appropriate manner, critically question circumstances, recognize and define problems, independently seek solutions, and critically examine their own actions" (p. 10). These

statements underscore the importance of autonomous learning and critical reflection as central educational goals.

Teaching

The curriculum emphasizes the extended role of the teacher in facilitating individualized learning. Teachers are tasked with “supporting young people in the search for answers to their questions and acting as facilitators in the development and consolidation of competences” (Austrian AHS Curriculum, 2023, p. 9). Furthermore, teachers are required to design competence-oriented lessons and “contribute to the achievement of overarching guiding principles and objectives through interesting, open, and student-oriented (*schülerinnen- und schülergerechten*) tasks” (p. 9). This perspective reflects a typical account of student-centered teaching, where the teacher primarily acts as a facilitator, moderator, and guide.

Learning

The first didactic model that is explicitly mentioned in the curriculum is found at the beginning of part three, “guiding principles”, and specifies its orientation towards the “4K model” as educational goal (Austrian AHS Curriculum, 2023, p.9). The 4K model of 21st century skills comprises four competences which are arguably of special importance in the 21st century. These competences are communication, collaboration, creativity, and critical thinking. In addition, this part of the curriculum also explicitly mentions its conception of learning. With respect to the concept of learning, the curriculum stresses that:

> More than the individual acquisition and reproduction of cognitive learning content. It is an active process in which young people are enabled to apply their knowledge and skills in groups to solve problems. The ability to work in a team is just as important as creativity to develop new solutions and the ability to critically evaluate one's own problem solutions (p. 9).

This demonstrates a multifaceted conception of learning, integrating social interaction, problem-solving, creativity, and critical thinking. Additionally, the curriculum introduces competence as a central concept. Competence is defined as “the interplay of knowledge, abilities (*Fähigkeiten*), skills (*Fertigkeiten*), and attitudes, activated in action situations through the disposition of the individual” (p. 10). Furthermore, it distinguishes between subject competence (*Sachkompetenz*), self-competence, and social competence, with the latter two seen as auxiliary competences developed alongside subject competence through activities such as collaborative learning. These competences aim to prepare students for situations requiring immediate problem-

solving beyond the scope of available knowledge and experience (p. 10). Here it seems that competence can be conceptualized as a relationship or a disposition rather than a catalogue of known facts.

Educational Areas

So far, the first section of the curriculum has stated the goals and purposes of its education, introduced the curricular conception, and provided initial insights into the didactic orientation of the curriculum.

The fifth and final part of the first section defines content points. These points, in addition to subject-specific knowledge, provide an overarching framework for the topical content of teaching practices at the upper secondary level. These content points are referred to as *educational areas* (Austrian AHS Curriculum, 2023, p. 10). An investigation into the characterization of these educational areas allows inferences to be made about the epistemology of the curriculum. According to the fifth part of the first section, “education is more than the sum of knowledge acquired in the individual subjects” (p. 10). This claim is used to justify the *educational areas* as a basis and contact point for interdisciplinary teaching (p. 10). What follows is a survey of the relevant claims made regarding the *educational areas*, which provide insight into the curricular epistemology.

In the *Language and Communication* area, it is argued that “the ability to express, think, communicate, and act is highly dependent on language competence,” as “worldview” and “cognitive structures” are “culturally and linguistically shaped (*geprägt*)” (Austrian AHS Curriculum, 2023, p. 10). Another area of interest with respect to epistemology is *People and Society*. Here, the curriculum states that “teaching must actively contribute to a democracy committed to human rights. The ability to judge and criticize as well as decision-making and action skills must be promoted; they are crucial for the stability of pluralistic and democratic societies” (p. 10). This indicates a clear intention to transmit specific values alongside subject-related knowledge. Furthermore, personal moral development is targeted through educational questions, as students are encouraged to engage with “religious and philosophical attempts to explain and justify the origin and meaning of one's own existence and the existence of the world,” which is described as “an important task of the school” (p. 10).

In the *Creativity and Creation* area, the curriculum emphasizes “thinking in alternatives, relativizing one's own points of view, developing a critical understanding, and recognizing diversity as a cultural quality” (p. 12). Creative work, according to the curriculum, should balance self-expression with social responsibility, fostering both individual enrichment and community-building.

1.3.3. Section 2: Competence Orientation

Section 2, *Competence Orientation*, is crucial for understanding the curricular epistemology, particularly its conception of knowledge, learning, and teaching. The first part of this section emphasizes the central role of competence orientation within the pedagogical framework of the curriculum. It begins by stating that the concept of competence is the curriculum’s key pedagogical principle (Austrian AHS Curriculum, 2023, p. 12). Consequently, understanding how competencies are characterized provides valuable insight into how learning is conceptualized. The curriculum refers to the *SchOG* in defining competencies as follows:

> According to § 8 lit. r of the School Organization Act, competencies are understood to be long-term cognitive abilities (*Fähigkeiten*) and skills (*Fertigkeiten*) that are developed by students, and which enable them to successfully and responsibly solve tasks in variable situations and to demonstrate the associated motivational and social readiness (p. 12).

From this definition, several characteristics of competencies, as understood by the curriculum, can be highlighted. Most importantly, competencies are stable abilities developed by students themselves; they cannot be directly transmitted by teachers. Instead, students become competent through active engagement in the learning process. Furthermore, competencies are acquired by solving tasks that require more than just subject knowledge, extending beyond memorization or understanding of facts and theories.

In addition to providing a general definition, the curriculum distinguishes three types of competencies. The first type is disciplinary (*fachliche*) competencies, which are subject-specific and detailed in Section 8 of the curriculum, focusing on individual subject areas. For example, disciplinary competencies in *Musical Education* include the ability to “understand and use musical vocabulary” (Austrian AHS Curriculum, 2023, p. 378) and to “listen to each other when making music and singing, grasping expression and aesthetic perception” (p. 379). The second type is extra-disciplinary (*überfachliche*) competencies, encompassing “motivation, self-awareness and

confidence in oneself, social skills, and learning method skills" (p. 12). Finally, the third type is interdisciplinary (*fächerübergreifende*) competencies, which are linked to the transdisciplinary topics specified in Section 4 of the curriculum. Examples include the ability to "recognize strengths and interests important for self-directed, reflective career and life planning" (p. 18) and to "communicate empathetically, provide constructive feedback, and present arguments in a debate" (p. 19).

Another didactic model introduced in the first part of Section 2 is "reflective basic education" (Austrian AHS Curriculum, 2023, p. 12). The curriculum states:

> Competence orientation is supported by the concept of reflective basic education. The aim of reflective basic education is that students are able to make critical judgments and continue learning independently at the end of lower secondary level (p. 12).

Although reflective basic education is mentioned as a complementary concept alongside competence orientation up to the end of lower secondary education, the curriculum does not elaborate on its practical implications or requirements. It merely states that students need to develop the abilities for critical judgment and independent learning.

The second part of Section 2, *Characteristics of Competence-Oriented Teaching*, provides the most explicit definition of learning found in the curriculum and outlines the teaching practices required to ensure successful learning (Austrian AHS Curriculum, 2023, p. 13). Learning is defined as:

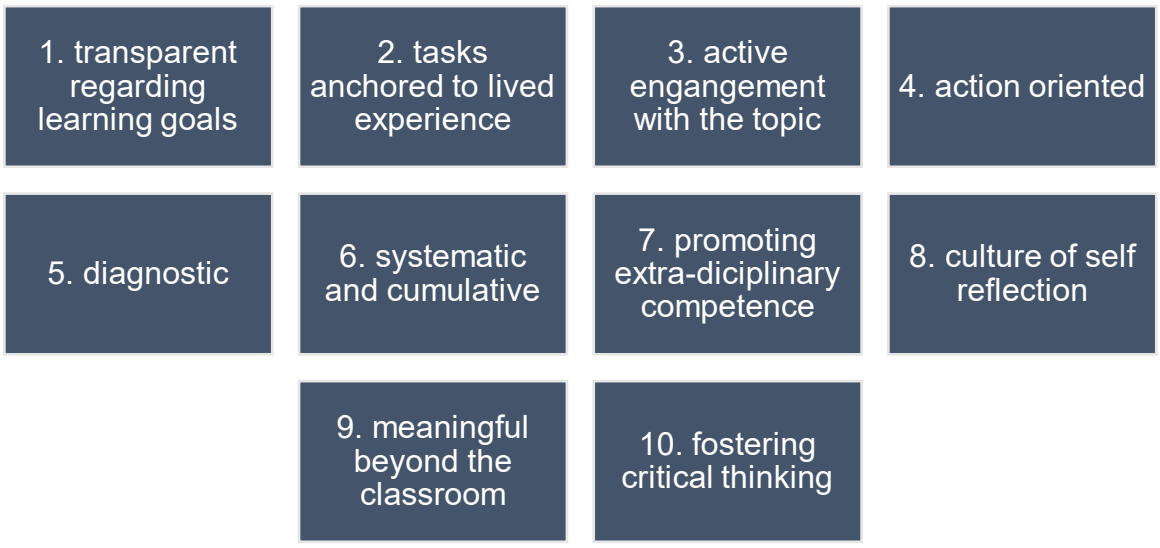
> An active, self-directed, reflective, situational, and constructive process in which the motivation and willpower of the students, their willingness to set and achieve goals, and their acceptance of objectives play an important role (p. 13).

The characteristics of learning described in the curriculum—activity, self-direction, situational context, and constructivity—align closely with the principles of constructivist learning theories. The curriculum emphasizes that learning is not the passive transmission of ideas but rather an active process undertaken by students themselves. This represents a learner-centered approach to education, which also informs the curriculum's perspective on teaching. Teachers are tasked with creating the conditions that facilitate the development of competencies, as explicitly stated in the curriculum (p. 13).

The curriculum specifies ten key characteristics of competence-oriented teaching (Austrian AHS Curriculum, 2023, p. 13). First, learning goals must be transparent. Second, tasks should align with the students' experiences and lived realities. Third, students should actively engage with the subject matter. Fourth, teaching must be action-oriented, encouraging the use of acquired knowledge for problem-solving. Fifth, lessons should incorporate diagnostic elements to address individual learning situations and facilitate insights. Sixth, knowledge growth must be cumulative, systematic, and interdisciplinary, with scientific insights presented in an age-appropriate manner. Seventh, extra-disciplinary skills, such as social competence, should be implicitly developed. Eighth, a "culture of self-reflection" should be cultivated to make students aware of their acquired skills and further motivate them to learn (p. 13). Ninth, lessons should provide meaningful learning experiences that extend beyond the classroom. Finally, the tenth characteristic is the encouragement of critical thinking.

Figure 4

Characteristics of competence-oriented teaching



1.3.4. Section 3: General Didactic Principles

In addition to the focus on the purpose and educational goals of the AHS in Section 1, as well as the elaboration of competence orientation as the central paradigm of the AHS in Section 2, Section 3 provides a clearer understanding of teaching by specifying principles to be observed by educators. While this section offers detailed directives for teaching practices, it primarily elaborates on the didactic approach outlined in previous sections rather than introducing fundamentally new insights. These principles serve to operationalize the curriculum's broader educational goals and ensure that the theoretical framework of Sections 1 and 2 is implemented in the classroom.

The first didactic principle requires teachers to consider the individuality of their pupils, taking into account their lived realities, including "experiences, interests, and preferences" (Austrian AHS Curriculum, 2023, p. 13). Teachers are tasked with providing individualized support and feedback, as well as promoting learning processes through varied settings and appropriate materials (p. 14). This principle aligns with the legal mandate outlined in Section 1, which emphasizes student individuality as a core concern of the educational process (p. 8). Building on this, the second didactic principle highlights the importance of integrating technology into teaching. Teachers are expected to "offer digitally supported teaching and use innovative learning and teaching formats" (p. 14). In addition to adopting technology-based methods, educators must remain open to new pedagogical, didactic, and subject-specific insights, continually evolving their teaching practices. The third principle places the focus on inclusivity. Educators are tasked with creating a learning environment that fosters positive social interaction and ensures participation free from discrimination. Teaching should also develop students' tolerance for ambiguity and diversity, equipping them to navigate complex societal challenges (p. 14). The fourth principle emphasizes careful lesson planning and the creation of a competence-promoting learning environment. Planning begins with an annual framework, from which shorter-term lesson plans are derived. The curriculum specifies:

> Included in the planning are competence-promoting tasks that are aimed at independent, exploratory, and inquiry-based learning in the sense of results orientation. In doing so, errors in the completion of learning tasks and in the learning process are permitted in order to use the deviation from the correct completion of the task as a learning moment (p. 14).

This principle highlights key didactic goals, such as fostering exploratory and inquiry-based learning, while promoting error tolerance as a tool for growth. Additionally, tasks

must be cumulative, systematically building on prior knowledge. Verbs associated with this process include “testing, exploring, discovering, inventing, collecting, systematizing, securing, and evaluating” (p. 14). The fifth principle centers on supporting students’ learning processes. Teachers are expected to encourage independent work wherever possible, selecting tasks that reflect students’ individual interests and inclinations. Feedback should also foster metacognitive awareness, enabling learners to reflect on and regulate their own learning (p. 15). Following this, the sixth principle underscores the importance of respectful interaction within the educational institution. This principle extends to the transmission of a liberal code of values and the provision of opportunities for students to critically reflect on their identities (p. 15). The seventh principle focuses on language-sensitive subject teaching. Students are expected to develop subject-specific language skills and vocabulary. According to the curriculum, “students must be able to use technical language, express thoughts and considerations, ask questions, name, depict, and describe objects, and grasp, justify, argue, and interpret facts” (p. 15). Teachers play a crucial role in facilitating the acquisition of subject-related vocabulary to ensure students can effectively engage with subject content. The eighth and final principle addresses feedback and assessment, emphasizing that these processes must be transparent and competence-oriented (p. 15).

In conclusion, Section 3 provides detailed specifications for teaching practices, translating the broader principles outlined in Sections 1 and 2 into actionable guidelines for educators. While it does not introduce fundamentally new epistemological insights, it elaborates on how teachers should operationalize the curriculum’s focus on competence and student-centered learning.

1.3.5. Competence Orientation as an Educational Paradigm

Outside the curricular notion of competence, the concept has been subject to debate in the broader pedagogical discourse of German-speaking countries. Sparked by the so-called “Pisa-Shock,” there has been a trend towards measurability and standardization of educational outcomes since the early 2000s (Lazarides et al., 2016, p. 277). In response to the relatively poor performance of German and Austrian students across multiple measures in comparative school performance studies, notably the PISA study (Programme for International Student Assessment) and the

TIMS study (Trends in International Mathematics and Science Study), German-speaking countries changed the focus of their educational policies. According to Lazarides et al., there was a paradigm shift from input orientation to output orientation, comprising a focus on educational standards and learning goals (2016, p. 277). Instrumental in this shift was the orientation towards measurable learning outcomes and competencies.

One of the most prominent definitions of competence was formulated by Weinert (2001). Weinert's definition of competence is foundational for many of the pedagogical conceptions inherent in the Austrian educational system, as multiple institutions in the educational system rely on it. Notably, national assessment initiatives such as the BiSt (Bildungsstandards) explicitly refer to Weinert's definition of competence, which comprises knowledge, ability, and motivational elements (Horak et al., 2010, p. 7). Competence, according to Weinert, refers to "the cognitive abilities and skills available to or learnable by individuals to solve specific problems, as well as the associated motivational, volitional, and social readiness and abilities to solve problems" (Weinert, 2001, p. 27f). In another definition of competence, Weinert states that he views

> 'competence' as referring to combinations of those cognitive, motivational, moral, and social skills available to (or potentially learnable by) a person or a social group that underlie the successful mastery through appropriate understanding and actions of a range of demands, tasks, problems, and goals (Weinert, 2001b, p. 2433).

A further interesting insight, apart from his definition of competence, is Weinert's conception of the relationship between subjects and the competences necessary to solve problems. He argues that

> subjects are not arbitrary conglomerates of knowledge but rather logical systems that students must acquire actively and constructively if they want to understand difficult content-related phenomena and problems in depth and if future learning is to be facilitated by transfer processes. This also applies to the processing of tasks that are embedded in non-subject-specific contexts but are subject-specific in nature. In order to successfully solve a mathematical problem that is situated in a socio-economic context, one needs the necessary mathematical knowledge and, at the same time, the interdisciplinary competences to be able to detach the task from the overarching factual context and use the result in a meaningful way to solve the non-mathematical problem (Weinert, 2001, p. 27).

This view essentially reflects a problem-oriented approach to knowledge and learning, in which the ability to acquire subject knowledge via understanding is one of multiple general cognitive skills (or competences), such as the ability to transfer knowledge into different contexts. It is the interplay between different competencies that facilitates successful action with respect to problem-solving.

Based on Weinert's perspective, which is fundamentally reflected in the curriculum, a brief characterization of the epistemology of competence orientation can be attempted. Knowledge, from a competence perspective, is aimed at being applied for solving problems and has to be conceptualized as one of at least three dimensions of competence. According to Walzik (2012), knowledge, in his interpretation of Weinert's competence model, refers to cognitive actions including "recognition" (Erkennen), "knowing," and "understanding" (p. 24). Apart from knowledge, Walzik defines two further dimensions of competence, namely values and attitudes on the one hand, and skills (Fertigkeiten) on the other (2012, p. 24). Regarding the learning process, Weinert's (2001) definition makes it explicit that competencies have a strong practical component in so far as they are problem-oriented on the one hand and must be developed over the course of a learning process, which itself is highly active and constructive. In the learning process, students construct in an autonomous and self-directed manner. Put in the simplest terms, to be competent, according to Weinert's (2001) understanding, means to be able to do something.

In their discussion of action competence, which draws on Weinert, Euler and Hahn (2014) argue that

> action competencies do not characterize one-off behaviors, but rather inner potentials or dispositions for stable, regular action in certain types of situations. It is therefore fundamental to distinguish between observable behaviors and the underlying competencies that make such behavior possible (p. 83).

This conclusion is also drawn by Walzik, who understands Weinert's competence description as viewing competence as potentials and dispositions (2012, p. 23). This means that competences are something more remote than behavior in the sense that they are less accessible in their measurability than behavior (Walzik, 2012, p. 23). Furthermore, it follows that competencies are not exhaustively described by theoretical understanding or factual knowledge of something, as knowing a fact does not yet make someone competent. Instead, knowledge is only one aspect of competence. Over the course of the learning process, the learner acquires knowledge and abilities and is also engaged on a motivational and social level in order to develop competencies.

This opens the question of the relationship between knowledge and skills, as Reusser (2014) argues that competencies are characterized by the connection of knowledge and ability. He elaborates, stating that

> competencies stand for a combination of level-graded (niveau-gestuften) subject-specific knowledge, content-related and process-related skills and abilities, and the results of subject-related and social learning that can be used across many subjects, including related interests, readiness, attitudes, and dispositions (Reusser, 2014).

However, critics of this view of the relationship between knowledge and skills argue that the correlation view, namely that knowledge and skills can run parallel to each other, is implausible because skills require knowledge (Arnold, 2013). Yet Reusser (2014) explicitly contends that skills are knowledge-based. It may be concluded that in the discussion of competence, the focus is removed from knowledge and broadened to include cognitive abilities like planning, monitoring, and transfer.

Digression: Examples of Competencies from the Subject Specific Curricula

Although examining theoretical considerations regarding competence in the broader educational discourse provides a slightly sharpened understanding of the vague and elusive notion of competence, it does not shed much light on how the curriculum makes use of the concept. To understand how the epistemology of competence orientation shapes the curricular conceptions of learning and teaching, it is useful to make a brief excursion into the subject-specific curricula and examine several examples of specified competences.

The first example is from the competence area “listening” in the first foreign language subject (e.g., English) in grade 3 at the lower secondary level. The competence goal is formulated as: “Students can understand simple conversations, stories, and short media contributions if they are spoken clearly and distinctly and not too quickly in standard language” (Austrian AHS Curriculum, 2023, p. 73). Another example from the same grade, in the competence area “speaking,” states that “Students can talk about familiar topics in simple language and give simple (book) presentations” (p. 73). A third example is from the subject of psychology in grade 7 at the upper secondary level. In line with part 3 of section 2 of the curriculum, competence goals at the upper secondary level are not explicitly stated (p. 13). Students are required, for example, to “explain and reflect on methods of psychology” (p. 245). In grade 8, in the subject of philosophy, students must be able to “assess philosophical issues” (p. 249).

The first point of interest is that competence descriptions at the lower secondary level are always formulated as can-do statements. Thus, the practical component and output orientation of competences become apparent in the formulation of competence

goals such as “can understand simple conversations” (p. 73). In line with Weinert (2001), the focus lies not on content knowledge alone, but the can-do formulation of competence goals indicates the presence of broader abilities at the intersection of knowledge and other cognitive skills.

Furthermore, with respect to the upper secondary level, an examination of the structure and requirements of the standardized Matura (Standardisierte kompetenzorientierte Reifeprüfung, SRDP) reveals interesting epistemological insights regarding the conceptualization of knowledge. In a guideline document for the design of competence-oriented tasks in line with SRDP requirements in the subject German, several points can be noted. First, the cognitive output of students is categorized into three areas of progressive “cognitive complexity,” each with its own set of descriptors, called “operators.” Regarding the learning theory informing the SRDP categorization, the guideline explicitly mentions Bloom’s taxonomy; however, it does not elaborate on how it was used to design the three areas of “cognitive complexity” (BMBWF, 2017, p. 8).

An introductory document on the operators in the subject German assigns specific operators to each area, some of which will be briefly highlighted (BMBWF, 2016). In the first area, “reproduction,” students are required to “name,” “describe,” and “summarize.” For the second area, “transfer,” students are, for example, required to “analyze,” “explain,” and “compare.” For tasks in the arguably most complex area, “reflection,” students need to “appeal,” “justify,” and “evaluate” (BMBWF, 2016, p. 3).

Figure 5

Operators for the SRDP in the subject of German

1 Operatoren, die Leistungen überwiegend im Anforderungsbereich *Reproduktion* verlangen	2 Operatoren, die Leistungen überwiegend im Anforderungsbereich *Reorganisation* und *Transfer* verlangen	3 Operatoren, die Leistungen überwiegend im Anforderungsbereich *Reflexion* und *Problemlösung* verlangen
1.1 (be)nennen	2.1 analysieren / untersuchen	3.1 appellieren
1.2 beschreiben	2.2 bestimmen / einordnen / zuordnen	3.2 begründen / Gründe angeben
1.3 wiedergeben	2.3 charakterisieren	3.3 beurteilen
1.4 zusammenfassen	2.4 erklären	3.4 bewerten
1.5 ...	2.5 erläutern	3.5 deuten / interpretieren
	2.6 erschließen	3.6 diskutieren / erörtern / sich auseinandersetzen mit
	2.7 in Beziehung setzen	3.7 entwerfen
	2.8 vergleichen / einander gegenüberstellen	3.8 kommentieren / Stellung nehmen
	2.9 ...	3.9 (über)prüfen
		3.10 vorschlagen / Vorschläge machen
		3.11 ...

Note. This figure is part of the document *Typen sprachlichen Handelns („Operatoren") in der SRDP Deutsch.* (BMBWF, 2016, p.3)

In summary, Section 2 of the curriculum elaborates on the central educational products—competencies. The curriculum distinguishes and emphasizes different forms of competencies that are meant to be developed jointly over the course of the teaching process. These three kinds of competencies are intended to encompass subject-related skills and knowledge, personal and social abilities, and connections to other subjects.

The theoretical framework of the competence model used in the curriculum can be traced back to Weinert's (2001) notion that competencies are dispositions that involve knowledge, skills, abilities, and social and motivational aspects. Furthermore, it is far from easy to precisely identify the conception of knowledge in the competence model. At the very least, it can be claimed to be an aspect of competence. One might argue that the curricular notion of knowledge involves ideas interwoven with the ability to practically apply them in specific situations. The mention of cumulative learning seems to imply a hierarchical structure of knowledge, with foundational lower levels and upper levels connected to knowledge of other disciplines. However, the concept of knowledge or a theory of knowledge remains unexplained.

With respect to learning, it seems accurate to claim that learning is not conceptualized solely as the acquisition of subject knowledge in terms of an ever-growing collection of facts or theories. Rather, the curricular notion of learning is an active, autonomous, reflexive, situated, and constructive process—one in which students must use their creativity and draw on several cognitive abilities to solve tasks.

Lastly, Section 2 of the curriculum makes it clear that competence-oriented teaching is subject to various characteristics. The overall goal of competence-oriented teaching may be said to aim at setting the conditions for students to develop competencies through meaningful and active engagement with the lesson content. In their lesson planning, it is important that educators see and respect students as autonomous individuals. This entails enabling personalized learning and diagnostics, providing opportunities to participate, and encouraging development through meaningful tasks and real-life-oriented lessons.

1.4. Interim Conclusion and Discussion: Knowledge, Learning, and Teaching According to the AHS Curriculum

The purposes of this section are to synthesize the key insights from the analysis of the curricular epistemology on the one hand and to formulate further questions on the other. First, there will be a brief review of the epistemology outlined in the first three sections of the curriculum. Then, assumptions will be derived from the review. Lastly, some problematic areas and open questions will be sketched, serving as the starting point for the second part of this research project—namely, the exploration of fallibilist epistemology and its potential to improve the epistemology underlying the curriculum.

Didactic Framework

The didactic framework of the curriculum is explicated in the first three sections. The structure of the curriculum can roughly be understood as a pyramid, with the first three levels controlling and setting the didactic stage for the lower levels, including the subject-specific curricula. Based on the didactic framework developed in these sections, the central paradigm of competence-orientation can be clearly identified. The curriculum repeatedly states that competence in its multiple forms is the central educational goal for students (e.g., Austrian AHS Curriculum, 2023, p. 10).

The focus on competences may stem from a shift from input orientation to output orientation in educational policy, largely influenced by the “PISA Shock.” Outcome-based education sets educational standards and learning goals with the purpose of ensuring measurability and transparency. This shift appears to have prompted an epistemic refocusing, replacing knowledge with competence. The curricular understanding of knowledge is not explicitly defined or elaborated upon but rather integrated as one aspect of competence, along with “skills, abilities, and attitudes” (Austrian AHS Curriculum, 2023, p. 10). This relegates the concept of knowledge to a supporting role in the epistemic framework established by the curriculum. Knowledge appears largely unattended, taken for granted, and subsumed under the broader concept of competence. This key product of the learning process—competence—is an ambiguous concept and is largely without explicit epistemic considerations in the curriculum.

It can, therefore, be argued that the epistemology of the curriculum is a blend of theories that are outcome-oriented and can broadly be placed in the overlapping areas of cognitivism and constructivism. Constructivist aspects of the curricular epistemology include the notion of learning as self-directed, autonomous, and situated within a social and cultural context. Additionally, the directive that the learning process should be individualized and that the teacher's role is that of a facilitator accompanying students in their learning points to constructivist principles in education.

Outside the curriculum, official documents published by the educational ministry highlight the theoretical framework underlying the SDRP and competence orientation (cf. Weiglhofer, 2013). This framework includes the revised version of Bloom's taxonomy, edited by Anderson et al. (2001). It is important to note that this taxonomy is not an explicit epistemological theory but rather a framework and classification scheme for setting educational objectives and designing assessment materials. It draws on both cognitivist and constructivist principles, particularly the idea that learners are constructive agents in their own learning (Anderson et al., 2001, p. 38).
The taxonomy distinguishes four knowledge dimensions and associated processes: factual knowledge, conceptual knowledge, procedural knowledge, and metacognitive knowledge (Anderson et al., 2001, p. 21). Regarding their view on knowledge, the authors assert:

> Based on cognitive science research on the development of expertise, expert thinking, and problem-solving, our perspective is that knowledge is domain-specific and contextualized. Our understanding of knowledge should reflect this domain specificity and the role that social experiences and context play in the construction and development of knowledge (Anderson et al., 2001, p. 41).

Furthermore, they view knowledge as "organized and structured by the learner in line with a rationalist-constructivist tradition" (Anderson et al., 2001, p. 41) and explicitly reject both a strict stage model of sequential learning, in which one type of learning must precede the other, and empiricist incremental learning (Anderson et al., 2001, p. 41). However, it seems that some of these notions, particularly the rejection of empiricist learning, have not been implemented in the curriculum.

Epistemic Assumptions in Line with the Curriculum

Based on the didactic framework laid out in the first three sections of the curriculum, the following claims can be made as reflecting the curricular conceptions of knowledge, learning, and teaching:

Knowledge	Learning	Teaching
K1: Knowledge is part of competence (p.10)	L1: Learning is an “active, self-directed, reflexive, situated, and constructive process”. (p.13)	T1: Teaching aims to take the students’ individuality into account. (p.8)
K2: The transmission of knowledge happens by raising awareness (p. 11)	L2: Learning is cumulative and systematic (p. 13)	T2: Teaching involves designing interesting and meaningful tasks (p.13)
K3: Knowledge, as a part of disciplinary competence must be “well-founded” (p. 10)	L3: Learning takes place over the course of problem-solving. (p. 13)	T3: Teaching has to convey foundational knowledge apart from helping to develop competences (p.11)

In order to ensure an appropriate level of fairness to the curriculum, some notes must be added to avoid mischaracterizations. First, with respect to K1, it must be noted that it is doubtful whether the curriculum actually conceptualizes knowledge exclusively as an aspect of competence. In a few places, the curriculum addresses knowledge and competence as separate entities (e.g., p. 9; p. 15). Regarding K2, it is not explicitly stated that knowledge transfer is achieved by raising awareness, nor is it argued that the curriculum conceptualizes raising awareness as a sufficient condition for acquiring knowledge. However, the emphasis on raising awareness for learning seems to be reasonably inferred from the descriptions of the “educational areas” in Section 2. There, it is stated multiple times that “awareness needs to be raised” for certain lesson content (p. 11, p. 12). Lastly, the attribute “well-founded” with respect to domain-specific knowledge is mentioned only once, but there is no reason not to classify the curricular epistemology as foundationalist.

Problematic Areas

These assumptions raise questions about what is missing and what can be improved, which become the focus of the following parts of this research project. Still, a brief presentation of problems and questions based on the analysis of the curriculum’s epistemological assumptions is warranted.

A major concern is the lack of conceptual clarity regarding knowledge. Throughout the first three sections of the curriculum, vague notions of the nature and structure of knowledge and its relationship to competence are presented. This lack of transparency makes it difficult to outline the epistemic assumptions underlying the curriculum. A deeper conceptualization of knowledge cannot be found in the general part of the

curriculum itself and must instead be pieced together, primarily from the descriptions of competence provided in the curriculum, the competence descriptions in individual subjects, and sources outside the curriculum.

One such source, the specification document for the SDRP, reveals a reliance on the revised Bloom's taxonomy (Weiglhofer, 2013). However, the curriculum does not explicitly mention Bloom's taxonomy as informing its perspective on knowledge. A similar issue arises with the absence of a clearly formulated learning theory in the curriculum. While learning goals are specified, the process of how to achieve them is largely left unaddressed. At most, characteristics of learning, such as activity, social embeddedness, and problem-solving, are referenced, allowing one to categorize the learning theory of the curriculum as relying on constructivist and cognitive principles.

Lastly, with respect to teaching, adhering to the curricular directives subjects teaching practices to a wide range of criteria that seem very difficult, if not impossible, to meet. The numerous principles and specifications for teaching render the claim of teacher autonomy dubious at best. Whether autonomy within such narrow parameters can still be called autonomy seems a pointless question.

Overall, the didactic framework of the curriculum appears vague regarding its epistemological approach, which is largely left implicit. Fortunately, this opens the possibility of incorporating explicit theories about key epistemic concepts such as knowledge, learning, and teaching. These theories may help to improve the design of the curriculum overall or at least contribute solutions to some of its epistemic problem areas.

Part 2: Discussion of Fallibilist Contributions to Epistemology with Relevance to Educational Theories.

This part of the research project aims to discuss theories and concepts from Popperian fallibilist epistemology, which may have the potential to enrich and improve the educational theory underlying the curriculum. In order to achieve this aim, this part is structured into three main sections. In the first section, Popperian epistemology will be presented. Initially, an overview of key principles of Popperian philosophy will be given. This section is followed by an illustration of how Popperian philosophy is a viable alternative to dogmatic and strongly relativistic theories. Then, the Neo-Popperian philosophy of David Deutsch is highlighted, and a short selection of his contributions to Popperian philosophy will be outlined. In the second section, contributions of Neo-Popperian epistemology with relevance to educational theory will be outlined, and common themes of Popperian educational theories will be presented. Then, the differences between Popperian learning theories and popular educational theories will be highlighted. In the third and concluding section, Popperian theories of learning will be surveyed. Lastly, the epistemology of the curriculum will be critically discussed from a Neo-Popperian perspective, and broad suggestions for modification will be offered.

2.1. Popperian Epistemology

This aims to familiarize readers with both Popperian philosophy and Deutsch's extensions of Popperianism. The concepts introduced here will be further discussed and related to the curriculum's epistemology. This segment begins with a quote from Karl Popper to outline key features of Popperian epistemology for readers who have not yet encountered it. Then, the relevance of Popper's philosophy will be argued for as a defense of a scientific worldview against forms of dogmatism and extreme forms of relativism. The discussion will conclude by exploring David Deutsch's Neo-Popperian philosophy, highlighting its significance as an extension of Popper's ideas and its potential implications for contemporary epistemology.

2.1.1. Three Principles of Popperian Epistemology

Karl Popper, who is mainly known as an epistemologist and philosopher of science, developed a highly consistent philosophy in the 20th century that he applied to a wide range of problems, from epistemology to scientific methodology, to the social sciences, as well as to moral problems. A key component of his philosophy is the view that he termed critical rationalism. He succinctly summarizes critical rationalism as the view that "I may be wrong and you may be right, and by an effort, we may get nearer to the truth" (OS, p. 431). Incidentally, this quote serves as a suitable starting point for novices to Popperian epistemology, as it already contains several implicit claims that distinguish this philosophical view. It also renders it incompatible with various historically influential epistemological positions that still inform parts of the scientific, philosophical, political, and educational spheres. Central to Popperian epistemology is the distinction between dogmatic thinking and critical thinking, which is applied to a wide range of areas concerning human knowledge. Critical thinking is of special importance in the Popperian picture of knowledge, and this explains his opposition to approaches to knowledge that, in Hans Albert's terms, "immunize" themselves against criticism (1972, p. 301f). To understand the basic principles of Popperian epistemology, the quoted formula about critical rationalism contains three concepts that will be briefly surveyed: truth, the fallibility of knowledge, and progress as resulting from the growth of knowledge.

Truth

First, the assertion that “we might get nearer to the truth” implies that something as objective truth exists that is accessible to the knowing subject. Indeed, Popper, accepting Tarski’s semantic theory of truth, argued for the existence of an objective and absolute truth (UQ, p. 98). However, Popper importantly claimed that achieving certainty about having true knowledge is impossible, even though objective truth exists. He argues that all one can do is detect and correct errors and thereby gradually approach truth. In this manner, he called truth a “regulative principle,” an ideal that can be approximated by detecting and correcting errors in one’s theories but never reached with certainty (CaR, p. 306f). This approach to truth marks Popper as a committed realist and adherent to the correspondence theory of truth. In other words, Popper’s realism establishes that there is an objective reality, irrespective of our beliefs about it. Furthermore, the correspondence theory is an idea of truth that claims assertions are true if they correspond to the facts (UQ, p. 141f).

It must be noted, however, that although some version of the correspondence theory of truth is commonly held, there are other popular rival theories of truth, such as the coherence theory, the consensus theory, the constructivist theory, and the pragmatist theory of truth, all of which seem untenable from a Popperian point of view (Niemann, 2008, p. 186f). In regard to finding the truth, Popper points out that even though we do not have a criterion that clearly distinguishes between truth and falsity, truth may be found by means of conjecture and criticism. Put differently, we make guesses about reality and subject them to criticism, which allows us to detect and correct errors and thus approximate the truth.

Popper stresses the fundamental importance of human languages in the rise of the idea of truth (OK, p. 119f). Based on Bühler’s language theory, he distinguishes four functions of human language. The first two, lower functions, encompass signaling and self-expression. Popper argues that people share these lower functions with animal languages and that the significance of human language is to be found mainly in its higher functions, the descriptive function and the argumentative function (OK, p. 119). It is with the descriptive function of language that “truth as a regulative idea” emerges (OK, p. 120).

Of course, the idea that an objective truth exists and is, in principle, accessible to us puts Popper's epistemology at odds with much of epistemic relativism. Popper strongly criticized certain versions of relativism. In his rejection of relativism, he points out that many relativistic doctrines rely on the denial of truth by the realization that there is no criterion for establishing the truth or falsity of a statement (FST, p. 488f). He writes, "the absence of a criterion of truth does not render the notion of truth non-significant any more than the absence of a criterion of health renders the notion of health non-significant. A sick man may seek health even though he has no criterion for it. An erring man may seek truth even though he has no criterion for it" (FST, p. 489). Thus, although Popperian epistemology and epistemic relativism generally agree that there is no reliable criterion capable of distinguishing truth from falsehood, Popperian epistemology retains the notion of an objective and reachable truth as the subject of knowledge.

Fallibilism

Secondly, Popper's succinct statement of "I may be wrong, and you may be right" implies fallibilism. Fallibilism in Popper's view means that all knowledge is prone to error and that there is no criterion that can establish final truth. This means that all knowledge must be, at least in principle, open to revision – or open to error correction. In *The Open* Society, Popper further paints a detailed picture of his understanding of fallibilism as he writes:

> By fallibilism I mean here the idea, or the acceptance of the fact, that we can be wrong, and that the search for certainty (and even the search for high probability) is a wrong search. But this does not imply that the search for truth is wrong. On the contrary, the idea of error implies that of truth as the patron saint that may not be attained. It implies that, while we may seek the truth, and may even find it (as it seems to me we do in many cases), we can never be quite sure that we have found it. There is always room for error, although in the case of some logical and mathematical proofs that possibility may be regarded as small. But fallibilism need not at all lead to sceptical or relativistic conclusions. This becomes clear if we consider that all known historical examples of human fallibility - including all known examples of miscarriages of justice - are examples of the progress of our knowledge. Each finding of a mistake constitutes a real advance in our knowledge... Therefore, we can learn from our mistakes. This fundamental perspective is, in fact, the basis of the whole epistemology and methodology. (CaR, p. 375-376)

There can be no doubt that relinquishing the quest for certainty, for Popper, does not imply that truth is unattainable. This is a key point in Popperian philosophy. Although the hopes of conclusively justifying any knowledge claim cannot be fulfilled, it is still possible to obtain true knowledge. Most importantly, this is achieved by finding and correcting errors in our theories and learning from our mistakes (MoF, p. 93). By virtue of the fallibility of all knowledge claims, there can be no genuine epistemic authorities.

Hence, all knowledge claims must be scrutinized and judged according to their content, not their source.

Popper's epistemology reflects a profound, though not naive, optimism about the growth of knowledge. In the Popperian view, the search for knowledge is always an open-ended endeavor. These two principles—optimism and openness—are encapsulated in the expression that "by effort, we might get nearer to the truth."

The principal method by which knowledge is created is trial and error, aimed at solving problems. For Popperians like Albert, this is the central idea behind all rational action (1985, xv). Knowledge is created by guessing and criticizing possible solutions to problems. Science is a special case of knowledge creation through problem-solving because it explicitly seeks to explain and adopts a critical attitude toward explanations (LSD, Preface 1959, p. xix). In other words, knowledge is created through conjectures and refutations, systematically eliminating errors in theories. This process results in an open-ended approximation of truth and the growth of knowledge. Popper writes:

> The possibilities that lie in the future are infinite. When I say 'It is our duty to remain optimists,' this includes not only the openness of the future but also that which all of us contribute to it by everything we do: we are all responsible for what the future holds in store. Thus, it is our duty, not to prophesy evil but, rather, to fight for a better world. (MoF, p. xiii)

Progress involves tackling increasingly refined problems, such as the historical shift from curing food to avoid starvation during winter to deciding how best to fill one's refrigerator for the week. It is a critical point to understand that progress does not mean that problems cease to exist; rather, they become increasingly refined. Lastly, progress entails mutual understanding and cooperation in the pursuit of knowledge. This, at least in part, depends on a certain personal attitude, namely the acceptance of the possibility of being wrong and the willingness to criticize one's own theories as well as those of others—in short, a critical attitude. In Albert's view, Popperian epistemology promotes such an attitude towards knowledge and thus encourages the transcendence of both relativism and dogmatism (2001, p. 135).

In summarizing key insights that educators can obtain from studying Popperian epistemology, one may note that all knowledge contains errors, and therefore the demand for certainty with respect to knowledge claims should be discarded. This, however, does not mean that one should be satisfied with their erroneous knowledge,

since all knowledge can be improved by adopting a critical attitude, detecting, and correcting errors. Lastly, in contrast to popular modern epistemic notions in educational theory and other spheres of knowledge, there is absolute and objective truth. People are able to obtain it; however, they can never be certain that it has been reached. It is therefore important not to demonize errors, for they are necessary in the creation of knowledge, and their detection and correction should be encouraged, as this is a key ingredient in any learning process. Furthermore, demanding certainty and secure sources is indeed a harmful and wrongheaded demand, as will be argued in further sections.

2.1.2. Popperian Epistemology in Defense of Rationality, Science, and Realism

It can legitimately be asked why Popperian epistemology should be relevant for educational matters at all. In trying to answer this question, it should be pointed out that one of the most valuable aspects of Popperian philosophy is that it provides tools for the critical evaluation of commonly held theories. Thereby, it has the potential to enrich our understanding of knowledge and its growth by identifying mistakes in prevalent theories. Another reason why Popperian epistemology is a highly attractive philosophical outlook is that it defends a scientifically informed worldview against extreme forms of relativism, which deny either the existence or the possibility of attaining objective knowledge. On the other hand, Popperian epistemology firmly rejects dogmatism in its many forms. Thus, Popperian fallibilism presents itself as a real and actionable alternative to both relativism and dogmatism in all areas of knowledge, including pedagogy.

Problem Solving by Conjecture and Criticism

Popperian epistemology centers on problem-solving through trial and error (ALiP, p. 3). This basic idea is applied to all forms of creating knowledge, scientific or otherwise. In the Popperian picture of knowledge, theories—or more precisely, the conflict between theories—always come first in the learning process (ALiP, p. 4). Such a conflict constitutes a problem. Our theories come from multiple sources, including inborn guesses, theories passed down to us in the form of traditions, or one's own creative speculation. Such prior knowledge forms the conditions for problems to arise (CaR, p. 62). Inevitably, our ideas clash and cause conflicts; they are incompatible or contradict each other. It is important to point out that this specific view of conflicts between ideas, referred to as a problem in Popperian epistemology, represents the starting point of the growth of knowledge.

In contrast to this problem-based view, some theories like empiricism claim that sense data enter our minds via sensory organs, which are then combined into knowledge (OK, p. 342). In essence, empiricism holds that knowledge is attained by virtue of sense perceptions and direct experience. Popper disagrees and claims that it is not experience that provides one with knowledge. In Popper's view, experience has a different but still critical role in the process of knowledge creation. Namely, experience

sets the conditions for problems to emerge as a living organism encounters problems. Most importantly, experience, including observations, is needed for its selective function in choosing between competing theories over the course of problem-solving (CaR, p. 36f).

The generality of Popperian epistemology marks its universal applicability, which is argued for and emphasized by Neo-Popperian philosopher and physicist David Deutsch (1996; 2013). According to him, Popperian epistemology applies to science as much as to philosophy and extends to everyday and vocational problem-solving. Furthermore, it applies equally to practical skills as well as purely theoretical knowledge. For educators, it is essential to understand that knowledge creation—learning—is fundamentally a process of problem-solving.

Defending Reason Against Relativism and Dogmatism

It has been established that error correction is one of the defining concepts of Popper's problem-oriented epistemology. Error correction is achieved through criticism. Popperian epistemology emphasizes rejecting knowledge claims that do not allow for criticism, thereby preventing error correction. Uncriticizability arises when alternative ideas are suppressed, thereby hindering progress (Deutsch, 1994). This aversion to criticism applies to various forms of dogmatism, which demand blind faith in knowledge claims and are therefore authoritarian. Relativism, the counterpart to dogmatism, also lacks criticizability as it rejects objective and absolute truth.

In Popperian terms, criticizability is the primary criterion for reason in all fields of human problem-solving (LSD, Preface 1959, p. xix). In *The Myth of the Framework*, Popper distinguishes a correct method of criticism from an incorrect one. He writes:

> We […] can logically distinguish between a mistaken method of criticizing and a correct method of criticizing. The mistaken method starts from the question: How can we establish or justify our thesis or our theory? It thereby leads either to dogmatism, or to an infinite regress, or to the relativistic doctrine of rationally incommensurable frameworks. By contrast, the correct method of critical discussion starts from the question: What are the consequences of our thesis or our theory? Are they all acceptable to us? (MoF, p. 60)

Popper himself has been highly critical of relativism in the sense that there are no obtainable objective truths, only truths relative to a belief system or a framework of assumptions. In *The Myth of the Framework*, he characterizes relativism as "the doctrine that truth is relative to our intellectual background, which is supposed to

determine somehow the framework within which we are able to think: that truth may change from one framework to another" (MoF, p. 33). In Popper's view, relativism of this kind has pervaded much of the intellectual sphere in the form of a narrative he termed the myth of the framework. He describes it as the misconception that "a rational and fruitful discussion is impossible unless the participants share a common framework of basic assumptions or, at least, unless they have agreed on such a framework for the purpose of the discussion" (MoF, p. 34).

This renders relativism unable to facilitate successful discussions, as every claim can be said to be true only in relation to its particular framework. This implies that there is "my truth" and another person's truth, or even class-based truths, but no way to determine who is closer to objective truth. According to the versions of relativism that Popper criticizes, objective truth does not exist. The consequence of such relativism is that it undermines reason and discussion as methods for resolving conflicts. The quest for truth thus degenerates into a power struggle between people who hold different "truths." Popper stresses that, in the absence of the possibility of successful discussions, relativism leads to anarchy and violence (AbW, p. 216).

Popper concedes, however, that although he views relativism as mistaken, it still contains genuine insights. For instance, it is often difficult to have a productive discussion between participants who see the world fundamentally differently, and, crucially, there is no criterion for truth (FST, p. 490). Popper's characterization of the myth of the framework suggests that belief systems essentially represent a prison of thought. Although he concedes that one's thought is influenced by one's culture, Popper argues that such a prison is easily escapable. One finds oneself quickly in a much larger prison, which in turn can be escaped into an even more spacious prison, ad infinitum (MoF, p. 61).

Apart from relativism, Popperian epistemology rejects all forms of dogmatism. Popper's main argument against dogmatism extends his rejection of authority with respect to knowledge. In *Conjectures and Refutations*, Popper argues against two main branches of dogmatism: epistemological pessimism and epistemological optimism. He claims that pessimism is connected to the "doctrine of human depravity, and it tends to lead to the demand for the establishment of powerful traditions and the

entrenchment of a powerful authority that would save man from his folly and his wickedness" (CaR, p. 7). This leads to authoritarianism and the suppression of human thought based on the pessimistic idea that knowledge is unattainable by individual humans and that they need someone or some ideology to "enlighten" them and thereby enslave them. On the other hand, Popper points out that the epistemological optimism expressed in the theory that "the truth is manifest" and clear for all to see, championed by diverse philosophers such as Bacon and Descartes, also leads to tyranny (CaR, p. 11).

Indeed, Popper asserts that

> the theory that truth is manifest—that it is there for everyone to see, if only he wants to see it—this theory is the basis of almost every kind of fanaticism. For only the most depraved wickedness can refuse to see the manifest truth; only those who have reason to fear truth conspire to suppress it. (CaR, p. 11)

It is not hard to see how the view that only those with evil intentions refuse to see the manifest truth leads to violence. Both epistemic pessimism and optimism, as characterized by Popper, place an emphasis on origin—the sources of knowledge: the empiricist bases their knowledge on sense perceptions and observation, while the intellectualist cites intellectual intuition or reason as the source of knowledge (CaR, p. 7). It must be noted that claims of certainty are often linked to the sources of knowledge through questions such as, "Where do you know this from?" or "What is your knowledge based on?" (CaR, p. 28).

Furthermore, various forms of dogmatism tend to draw upon a version of epistemic optimism or pessimism and seek to establish authority to discern truth, thereby avoiding critical discussion of their source of knowledge. According to Popper, no source has authority in the sense that it can reliably distinguish between truth and falsity (CaR, p. 36). Every attempt to find an ultimate source of truth must fail. Therefore, the question of how to find reliable sources for our knowledge ought to be replaced by the question, "How can we hope to detect and eliminate error?" (CaR, p. 33). The Popperian answer to this question is by adopting a critical attitude toward both our own theories and the theories of others (CaR, p. 34). The critical attitude is the best precaution against dogmatism and involves the acknowledgment of one's own fallibility.

Science

The greatest impact of Popperian epistemology is found in his philosophy of science; he published *The Logic of Scientific Discovery* in 1934. For Popper, science is the rational practice of growing our knowledge through conjecture and refutations and, as such, represents simply a special case of common-sense knowledge creation (LSD, Preface 1959, p. xxii). The basic process of science can be summed up in one sentence: In reaction to the emergence of problems, the scientist proposes conjectures in the form of hypotheses and subjects them to rigorous tests. What characterizes science and distinguishes it from pre-scientific knowledge creation is that, in science, one is actively trying to find errors in a theory and thus eliminate the theory as a viable solution to a problem. In contrast, in pre-scientific knowledge creation, the errors of an attempted solution to a problem become apparent through feedback from the environment when one's solution to a problem fails (ALiP, p. 9).

Popper writes about the scientific process, saying that “science should be visualized as progressing from problems to problems—to problems of ever-increasing depth” (CaR, p. 301). The starting point for the progression of science is, therefore, different from other conceptions of science. Rather than starting with observation, Popper stresses that the growth of scientific knowledge, like any other knowledge, always starts with problems (MoF, p. 95). These problems may arise from unconsciously held expectations that conflict with the real world or from consciously constructed attempts at explanation that do not hold up. At any rate, problems are caused by “a theory which has raised, and disappointed, certain expectations” (MoF, p. 96).

Popper further emphasizes the role of imaginative creativity in guessing explanations. Humans have always tried to explain the world, initially in the form of myths. The birth of the critical attitude toward myths marks the invention of science, as Popper writes:

> Science must begin with myths, and with the criticism of myths; neither with the collection of observations nor with the invention of experiments, but with the critical discussion of myths and of magical techniques and practices. The scientific tradition is distinguished from the pre-scientific tradition in having two layers. Like the latter it passes on its theories; but it also passes on a critical attitude towards them. (CaR, p. 66)

Another special feature connected with the critical attitude is the demand for the criticizability of scientific statements. This important factor includes testability with respect to scientific hypotheses, as the falsification of the hypothesis can refute the theory. Popper argues that “a theory which is not refutable by any conceivable event

is nonscientific. Irrefutability is not a virtue of a theory (as people often think) but a vice." (Popper CaR, p. 48). Furthermore, if one takes the demand for testability seriously, then it follows that every scientific theory, by virtue of its testable hypotheses, forbids certain events from happening. For example, the axial tilt theory of the seasons prohibits uniform seasons on all parts of the earth simultaneously. Thus, in Popper's view "every good scientific theory is a prohibition: it forbids certain things to happen. The more a theory forbids, the better it is" (CaR, p. 48). This is because "only a theory which asserts or implies that certain conceivable events will not, in fact, happen is testable. The test consists in trying to bring about, with all the means we can muster, precisely these events which the theory tells us cannot occur." (MoF, p. 94)

Lastly, the objectivity of scientific knowledge is not due to the individual scientist being more objective than non-scientists. Rather, for Popper, the institutionalized "friendly-hostile cooperation of scientists' that is, their readiness for mutual criticism, which makes for objectivity" (MoF, p. 93).

2.1.3. Neo-Popperian Fallibilism

Popperian epistemology has been accepted, rejected, criticized, and adapted by a diverse range of individuals, including scientists like Einstein, politicians such as Margaret Thatcher and Helmut Schmidt, and philosophers like Lakatos and Feyerabend, both sympathetic and antipathetic to Popper's ideas. Currently, there has been a development of Popperian philosophy led by a prominent contemporary proponent of Popperian fallibilism, British-Israeli physicist David Deutsch. His epistemological work is laid out in his two books, *The Fabric of Reality* and *The Beginning of Infinity*, which serve as major sources in the discussion of contemporary Neo-Popperianism.

Even though he claimed to have merely provided "footnotes to Popper" (Ravikant, 2023a), Deutsch has contributed original ideas to Popper's work and thereby adapted and extended Popperian philosophy for the 21st century. Among Deutsch's many contributions are his expansion of Popper's epistemological optimism, his discussion of contemporary mistaken philosophies of science like instrumentalism, his case for the universality of human explanatory knowledge as a consequence of the Turing principle, and his criteria for good explanations.

The Infinite Reach of Knowledge

One of Deutsch's most notable contributions to Popperian epistemology is his claim that the universe is exhaustively explicable by human knowledge creation due to the universality of computation and epistemology. This view significantly extends the power of knowledge beyond the limits imposed by relativist accounts. He asserts that, in principle, the reach of human knowledge is infinite. However, in line with critical rationalism, he maintains that humans will never have a guaranteed grasp of the truth—they are always at the beginning (Deutsch, 2011, p. 65).

Deutsch's argument for the potentially unlimited reach of human knowledge begins with his assertion of the comprehensibility of the universe. This assertion considers the self-similarity of physical reality, including the equal applicability of the fundamental laws of physics across the entire universe. In this framework, human minds, as creators of knowledge, play a pivotal role. Deutsch views human thought as a form of computation (1998, p. 122). The human mind is, in essence, a virtual reality generator capable of rendering any physically possible environment. In his view, every sensory perception, thought, and any cognitive process is a virtual reality rendering. This is made possible by the universality of computation, stated by the Turing principle in its most far-reaching form, as formulated by Deutsch: "It is possible to build a virtual reality generator whose repertoire includes every physically possible environment" (1998, p. 135). About the comprehensibility of physical reality, Deutsch writes:

> If the laws of physics as they apply to any physical object or process are to be comprehensible, they must be capable of being embodied in another physical object - the knower. It is also necessary that processes capable of creating such knowledge be physically possible. Such processes are called science. Science depends on experimental testing, which means physically rendering a law's predictions and comparing it with (a rendering of) reality. It also depends on explanation, and that requires the abstract laws themselves, not merely their predictive content, to be capable of being rendered in virtual reality. This is a tall order, but reality does meet it. That is to say, the laws of physics meet it. The laws of physics, by conforming to the Turing principle, make it physically possible for those same laws to become known to physical objects. Thus, the laws of physics may be said to mandate their own comprehensibility. (1998, p. 135)

Even more than the fortunate fact that the universe itself is comprehensible, the key point is that humans are the knowers alluded to in the quote. For Deutsch, a human shares the same functionality as a universal computer—it can compute anything that is physically possible given enough memory and processing speed. The implications for educational theories are clear: human minds, by virtue of critical imagination, are able to comprehend anything. In all important ways, then, the reach of human

knowledge is infinite. This perspective leads to viewing students as universal explainers—entities who, if not severely disabled, are not, in principle, cognitively closed to any particular piece of knowledge. In principle, students can learn anything, as the constitution of their minds, coupled with the universality of computation, enables them to render anything that the laws of physics permit.

Against Instrumentalist Accounts of Science

Apart from the infinite reach of human knowledge, Deutsch expands Popper's philosophy of science by focusing on the concept of explanation. Deutsch argues that Popper's criterion of demarcation is insufficient to characterize the scientific method or hint at its purpose (2011, p. 14). This is because testable predictions are ubiquitous, as "every would-be prophet who claims that the sun will go out next Tuesday has a testable theory" (2011, p. 14). Thus, science must go beyond providing mere testable predictions. The main goal of a theory is to provide an explanation—a "statement of the reality that accounts for the appearance" (2011, p. 15).

Deutsch illustrates this point with the example of a conjuring trick. It is a perfectly testable prediction to claim that a ball will not be in a cup, but this tells us nothing about how the trick works (2011, p. 15). An explanation is needed. The same logic, according to Deutsch, applies to the scientific outlook known as instrumentalism, which aims to advance explanation-free theories by claiming that science is solely about predicting the outcomes of observations (2011, p. 15). He argues:

> The quest for good explanations is, I believe, the basic regulating principle not only of science, but of the Enlightenment generally. It is the feature that distinguishes those approaches to knowledge from all others, and it implies all those other conditions for scientific progress I have discussed: It trivially implies that prediction alone is insufficient. Somewhat less trivially, it leads to the rejection of authority, because if we adopt a theory on authority, that means that we would also have accepted a range of different theories on authority. And hence it also implies the need for a tradition of criticism. It also implies a methodological rule – a criterion for reality – namely that we should conclude that a particular thing is real if and only if it figures in our best explanation of something. (2011, p.22f)

In summary, Neo-Popperian Fallibilism provides logically consistent reasons and specific criteria for rejecting theories on the grounds of being bad explanations (e.g., conspiracy theories) across all domains of knowledge creation. It also equips individuals with tools to pursue the quest for good explanations.

2.2. Neo-Popperian Concepts Relevant to Educational Theories

This segment focuses on Popperian concepts relevant to curricular epistemology. The primary thinkers whose ideas are drawn upon are Karl Popper, Hans Albert, and David Deutsch. Their concepts guide the discussion of epistemic principles that can inform a more adequate theory of knowledge in the curriculum. The central problem addressed in this section is the nature of knowledge and learning from a Popperian perspective. The section begins with a discussion of rational practice, then sketches the Popperian account of knowledge, and concludes with a discussion of learning from a Popperian point of view. The insights from this section will inform the discussion of educational theories and curricular epistemology in the following sections.

2.2.1 Rationality and the Problem of Foundations

Knowledge and rationality are two concepts that are often intertwined in popular discourse. Rationality, or reason, as opposed to irrationality or unreason, is a fraught set of terms frequently used to categorize people as either reasonable or unreasonable, as observed by David Deutsch (2023). However, the human capacity for reason can be seen as a precondition for creating explanatory knowledge. Hans Albert writes,

> the problem of rationality is a general problem of human practice and is […] not limited to the sphere of knowledge or of cognitive practice. Human reason is competent in all realms of problem-solving behavior. At the same time, reason is also fallible in these realms, from logic and mathematics—where some people are inclined to see a province of certainty—to all other sciences, and of course also to philosophy, to law and politics, and to religion, where some people would like to make an exception. (1985, p. xv)

Frequently, reason is understood in terms of having good reasons to believe something. For instance, my belief that the street is wet seems reasonable if it has rained recently. Once reasons are identified as what justifies knowledge, one is quickly led to ask about epistemological “bedrock,” a solid foundation on which to base one’s knowledge. The intuitive idea behind this is that, once one finds the ultimate justification, one arrives at a firm basis from which authoritative knowledge can be derived. This essentially becomes the defining question for determining a criterion for genuine knowledge: Is the knowledge claim derived from a secure source?

Justificationism and the Principle of Sufficient Reason

Popperians, along with other anti-justificationist schools, have argued that the search for ultimate foundations or secure sources is fundamentally mistaken. Popper even claimed that it was the wrong question to ask all along (CaR, p. 33). In Popperian epistemology, rationality and the growth of knowledge are not about basing knowledge on secure sources or having good reasons for believing something. Indeed, the very concept of justification as an epistemic criterion is rejected. Against the notion that knowledge requires justification, Deutsch argues as follows:

> The misconception that knowledge needs authority to be genuine or reliable dates back to antiquity, and it still prevails. To this day, most courses in the philosophy of knowledge teach that knowledge is some form of justified, true belief, where 'justified' means designated as true (or at least 'probable') by reference to some authoritative source or touchstone of knowledge. Thus 'how do we know . . . ?' is transformed into 'by what authority do we claim . . . ?' The latter question is a chimera that may well have wasted more philosophers' time and effort than any other idea. It converts the quest for truth into a quest for certainty (a feeling) or for endorsement (a social status). This misconception is called justificationism. (2011, p. 9).

For Deutsch, therefore, a criterion for distinguishing truth from falsehood does not exist, and much of the philosophy of knowledge is misguided in its search for a definitive way to justify knowledge claims. However, despite the absence of a criterion of truth, Popperians maintain that genuine knowledge is still attainable. To understand the concept of reason that Popperians advocate, it is useful to examine the example of empiricism. Numerous candidates have been proposed as secure sources of knowledge, one of which is sensory experience.

The Role of Experience

The empiricist views experience as foundational, in the sense that knowledge is based on sensory data. From this sensory data, theories are extrapolated through induction. Popperians, however, are critical of both the notion of knowledge as a product of sensory data and observation on the one hand, and the process of induction on the other. Regarding observation as a foundation, Popper argues that observation itself is not eligible to qualify as a source of knowledge since,

> observation is always selective. It needs a chosen object, a definite task, an interest, a point of view, a problem. And its description presupposes a descriptive language, with property words; it presupposes similarity and classification, which in their turn presuppose interests, points of view, and problems. (CaR, p. 61)

Observations, and indeed any sensory experiences, are already imbued with theories; they occur within a theoretical framework. There is nothing infallible about "direct experience" either. In fact, experience is never truly direct. It is a sort of virtual reality

created by our brains using flawed sensory clues, given substance only by fallible expectations, explanations, and interpretations. Experience, Deutsch argues, provides problems that serve as the starting point for rational practice (2011, p. 120). However, experience never provides theories. Instead, experience brings existing ideas into conflict, thereby creating problems.

Anti-Foundationalism

Hans Albert is known for his formulation of the Münchhausen Trilemma as a response to the perceived need to place knowledge on a firm basis. The idea behind the Münchhausen Trilemma is that any effort to arrive at an ultimate justification that would function as a foundation for knowledge fails in one of three ways (1985, p. 18). Consider the statement: “Scientific knowledge is justified by empirical observations.” The first way leads to an infinite regress, as the observations establishing scientific knowledge would require justification by preceding observations, which themselves would need to be justified by further observations, and so on ad infinitum.

The second way is the logical circle that arises when one argues that empirical observations are validated by scientific methods, which, in turn, are based on empirical observations. This is a classic example of a metaphorical snake biting its own tail and does not result in ultimate justification. Lastly, a dogmatic breaking-off point might involve simply declaring the statement to be (manifestly) true and therefore justified, paralleling the doctrine that truth is manifest (Albert, 1985, p. 19).

In Albert's view, the search for a firm foundation of knowledge inevitably comes to an unsatisfactory end. Thus, the model of rationality that demands good reasons in the form of secure foundations for belief ultimately fails.

Rational Practice

If acting rationally does not mean searching for good reasons to justify one’s beliefs, what does rationality consist of? Deutsch writes,

> the inherent limitation on human reason, that it can never find solid foundations for ideas, does not constitute any sort of limit on the creation of objective knowledge nor, therefore, on progress. The absence of foundation, whether infallible or probable, is no loss to anyone except tyrants and charlatans, because what the rest of us want from ideas is their content, not their provenance. (2013)

Rational practice, in Popperian terms, primarily refers to an open and critical attitude with the intention of solving problems. Problem-solving and criticism are the two fundamental components of rational practice in the Popperian theory of knowledge. All fields of knowledge in which problem-solving occurs qualify as fields of rational thought. The domain of rational practice, therefore, includes science, epistemology, morality, and all other human endeavors where progress can be made by adopting a critical attitude.

Error correction, as a consequence of criticism, is one of the most important aspects of rational practice, enabling progress. For Popper, the growth of knowledge occurs by learning from our mistakes (CaR, p. 310). This leads to the insight that what distinguishes rational practice from irrationalism is the attitude toward criticism. For Deutsch,

> it's all about error. We used to think that there was a way to organize ourselves that would minimize errors. This is an infallibilist chimera that has been part of every tyranny since time immemorial, from the "divine right of kings" to centralized economic planning. And it is implemented by many patterns of thought that protect misconceptions in individual minds, making someone blind to evidence that he isn't Napoleon, or making the scientific crank reinterpret peer review as a conspiracy to keep falsehoods in place. (2013)

Irrationalism, therefore, is found in any doctrine that inhibits, disables, or suppresses people's critical faculties. According to Deutsch,

> the theory of knowledge is a tightrope that is the only path from A to B, with a long, hard drop for anyone who steps off on one side into "knowledge is impossible, progress is an illusion" or on the other side into "I must be right, or at least probably right." Indeed, infallibilism and nihilism are twins. Both fail to understand that mistakes are not only inevitable, they are correctable (fallibly). Which is why they both abhor institutions of substantive criticism and error correction, and denigrate rational thought as useless or fraudulent. They both justify the same tyrannies. They both justify each other. (2013)

Popperian epistemology rejects the demand for secure sources of knowledge as fundamentally mistaken. Any source can be used, provided it is not regarded as infallible, and the attempt to ground one's reason in a secure foundation is hopeless. Rather than seeking an epistemic authority, it is error correction and the critical attitude that distinguish rational practice from irrational practice.

2.2.2. The Nature of Knowledge: A Survey and Critique

One of the most important questions in epistemology concerns the nature and structure of knowledge. To grasp the far-reaching implications of some philosophical theories, one must recognize that the question regarding the nature of knowledge is, at least implicitly, answered in any learning theory and, consequently, in every didactic framework. It follows, then, that the curriculum, as a prescriptive document, implicitly incorporates epistemological theories that may be flawed. In the following section, Popperian fallibilism is adopted to first examine what knowledge is not, which is used as a means to refine the curricular understanding of knowledge in the later sections. Lastly, the Popperian conception of knowledge will be outlined.

The Commonsense Theory of Knowledge

Popper praises common sense as a good guide in most practical applications. In *Objective Knowledge*, Popper devotes many pages to illustrating his view of common sense and argues that "science, philosophy, rational thought, must all start from common sense," although, like all sources of knowledge, it is a fallible starting point (OK, p. 33). Moreover, one of the wisest qualities of "enlightened common sense" is its realism—the metaphysical view that there is an external world which exists objectively (OK, p. 37).

Despite his appreciation of common sense, Popper sharply critiques its epistemological underpinnings for several reasons. First, it asserts that knowledge comes to us through our senses and thereby stipulates a secure source of knowledge, which, according to Popper, does not exist (OK, p. 60). Second, based on its reliance on sources, it portrays the mind as a knowledge receiver—a passive vessel to be filled with knowledge by the senses. In this view, secure sources pour knowledge into this vessel, causing knowledge to grow by accumulation. Popper refers to this as the "bucket theory of mind" (OK, p. 61). He argues that this mistaken view of the mind leads to gravely flawed perspectives regarding the nature of knowledge. These views may be summarized as epistemic associationism, which relies on knowledge as discrete elements or particles of sense data or ideas. In this atomistic view of knowledge, learning—or the growth of knowledge—is the reception of data through the senses, which is then "digested" (OK, p. 61). Thus, undigested knowledge that enters through the senses is considered direct (veridical) and "in us." Lastly, higher-level

knowledge is formed by associations of ideas beyond mere sense perception (OK, p. 62).

Third, the common-sense theory fails to distinguish between objective and subjective knowledge. It tends to conceptualize knowledge as a subjective state of belief with an associated feeling of certainty—a justified true belief. According to Popper, the common-sense theory of knowledge exhibits a strange mixture of objectivism and subjectivism, as “the most certain knowledge we can have is about ourselves and our observational or perceptual experiences” (OK, p. 104). In other words, the common-sense theory of knowledge incorporates the subjectivist notion of justified belief, where the best justification for belief—and the source of certainty—is found in one’s direct experiences, consisting of sense perceptions or ideas formed by associating sense data. However, Popper concludes that this view is fundamentally flawed.

Another fundamental critique is its failure to acknowledge that all sense impressions and experiences are inherently theory-laden. In Popper’s theory of knowledge, there is no such thing as direct or veridical experience; even experience is conjectural and prone to error. Simply put, the common-sense theory of knowledge, as conceptualized by Popper, manifests in the attitude that “if I have seen it, then it is true.” According to this view, “my experiences are more authoritative than others’ theories,” as one’s own experiences are perceived as the best source of knowledge. Of course, Popper rejects this view as hopelessly mistaken.

Justificationism: Knowledge as Well Founded

A central problem in epistemology is how to choose between theories. Popper argues that historically, this problem has been connected to the question of how we justify theories (RaS, p. 19). A common answer to the second question is that knowledge is justified once it is based on a secure foundation. According to Popper, this doctrine—that knowledge is well-founded or justified—has pervaded epistemology for much of its history.

In general, Popperians present two kinds of arguments against justificationism. First, they demonstrate that arriving at a solid foundation or ultimate justification is logically untenable. As Albert illustrated in his *Treatise*, all attempts to achieve ultimate

justification end in one of three unacceptable ways, as explained by the Münchhausen Trilemma presented earlier. Another argument of this kind refutes the persistent misconception that knowledge can be built on a secure foundation based on sense data, observation, and inductive theory formation—a view that remains popular.

The second type of argument is moral and pragmatic. Justification is often misused as a guarantee of truth, leading to epistemological authoritarianism. It is this authoritarianism that impedes progress and coerces individuals. Deutsch underscores this point by referencing a modified quotation from Popper's 1960 lecture, *Knowledge Without Authority* (Popper, 1960, p. 52). Deutsch phrases it:

> The question about the sources of our knowledge . . . has always been asked in the spirit of: 'What are the best sources of our knowledge – the most reliable ones, those which will not lead us into error, and those to which we can and must turn, in case of doubt, as the last court of appeal?' I propose to assume, instead, that no such ideal sources exist – no more than ideal rulers – and that all 'sources' are liable to lead us into error at times. And I propose to replace, therefore, the question of the sources of our knowledge by the entirely different question: 'How can we hope to detect and eliminate error?'. (2011, p. 209)

For Popper one of the most dangerous false ideas about knowledge is the doctrine of manifest truth. It is used as a legitimization tactic to establish epistemic authority. He cautiones that:

> The theory that truth is manifest—that it is there for everyone to see, if only he wants to see it—this theory is the basis of almost every kind of fanaticism. For only the most depraved wickedness can refuse to see the manifest truth; only those who have reason to fear truth conspire to suppress it. (CaR, p. 11)

In summary, Popperian epistemology firmly rejects justificationism. First, it argues that the pursuit of ultimate justification is inherently futile. Second, it cautions that faith in the possibility of infallible knowledge fosters authoritarianism.

Knowledge as Reducible to Definitions

Another misconception about knowledge is that it can be found in definitions and that the growth of knowledge results from an ever-growing collection of definitions that capture the "essence" of what is to be known about something. According to Popper, such essentialist definitions aim to answer "what is" questions, which assert truth (OS, p. 230).

Popper critiques this view, contending that definitions are merely operational tools, useful only to "cut a long story short" (OS, p. 230). Consequently, he assigns relative unimportance to definitions, maintaining that they must only be as precise as the

problem demands. In his critique of essentialist accounts of explanations, Popper argues:

> I reject all what-is questions: questions asking what a thing is, what is its essence, or its true nature. For we must give up the view, characteristic of essentialism, that in every single thing there is an essence, an inherent nature or principle (such as the spirit of wine in wine), which necessarily causes it to be what it is, and thus to act as it does. This animistic view explains nothing; but it has led essentialists (like Newton) to shun relational properties, such as gravity, and to believe, on grounds felt to be a priori valid, that a satisfactory explanation must be in terms of inherent properties (as opposed to relational properties). (OK, p. 195)

For Popper, knowledge is to be found in theories rather than in collections of definitions. An encyclopedic view of knowledge, when applied to educational theory, treats knowledge as a catalog of definitions containing the relevant informational content. This approach neglects the fundamentally problem-driven nature of knowledge creation.

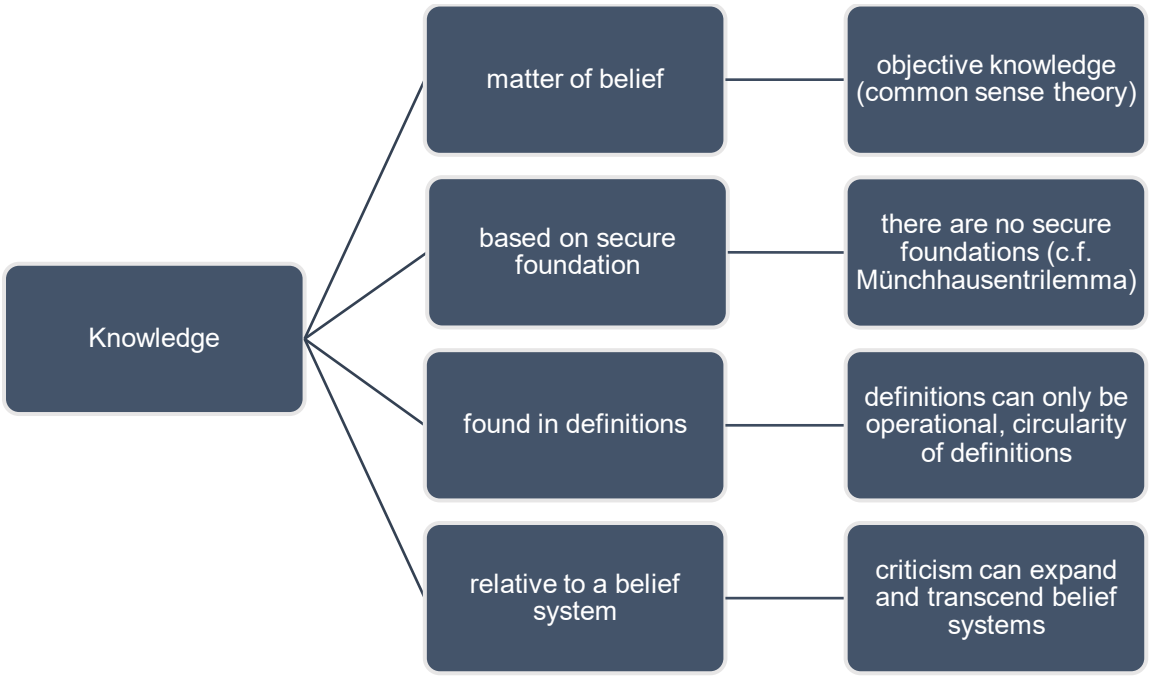
Knowledge as Only Relative to a Certain Belief System

The final misconception regarding the nature of knowledge is the widespread belief that knowledge is only relative to a certain belief system. This misconception disregards truth as a regulative idea and constitutes a form of anti-realism. According to Albert, this relativistic perspective has been influenced by transcendental idealism, fracturing the single Kantian framework into multiple incommensurable relative frameworks meaningful only to certain groups (Albert, 2001, p. 129).

This version of relativism, sharply criticized by Popper, is encapsulated in the relativist *myth of the framework*, which posits that we are all subject to mental frameworks that act as prisons (MoF, p. 53). Popper concludes that this account underestimates the power of the critical attitude emphasized in critical rationalism. Criticism allows frameworks to be questioned and replaced with broader, more encompassing perspectives. In Popper's view, one escapes from one prison to a larger one, then to an even larger one, ad infinitum.

The idea that knowledge is relativistic and anchored to untranslatable sociocultural frameworks holds that knowledge is inextricably culture-bound and that intercultural understanding is possible only if one framework is accepted (Albert, 2001, p. 136). This position is tenable only if realism and objective truth are denied, and the unifying role of criticism is ignored.

Figure 6.
Misconceptions regarding knowledge



The Nature of Knowledge

Popper's account of knowledge is decidedly anti-justificationist. According to him, no knowledge claim can be justified because there is no reliable method to ascertain the truth of a statement (RaS, p. 19). In other words, knowledge is not based on anything. There is no such thing as a reliable source or an authority with respect to knowledge. However, objective knowledge is attainable, and three components are necessary to achieve it: problems, guessed explanations or solutions, and criticism as a means of error elimination. In the absence of genuine authorities regarding truth, knowledge claims must be evaluated by their content rather than their source. This evaluation notably includes both the authors and the methods by which the knowledge was obtained. Fallibilism, therefore, presents a non-authoritarian solution to prominent concerns in classical epistemology, such as theory selection and the illusory need for justification.

Objective knowledge must be disentangled from certainty, which merely represents a mental state. To achieve this, Popper's *Three Worlds Ontology* is a helpful concept. Popper introduces this framework to denote three aspects of reality that exist objectively (OK, 106ff). He asks us to imagine three different worlds and specifies the relationships between them.

- **World 1**: The physical world, encompassing objects like trees, rocks, water, houses, and human bodies. Anything made of matter qualifies as part of World 1.
- **World 2**: The world of mental states, including consciousness and qualia. Subjective knowledge, such as the feeling of certainty about a theory or emotions, also belongs here.
- **World 3**: The world of abstract content, such as the knowledge contained in theories, art, and their associated problems.

Popper argues that knowledge of World 3, namely objective knowledge, is the most important. Traditionally, epistemologists have focused on World 2 knowledge when, in truth, epistemology concerns knowledge of the World 3 kind. Through objective knowledge, we come to understand both our mental lives and physical reality; thus, World 3 feeds back into Worlds 2 and 1 (OK, p. 147).

Building on Popper's understanding of knowledge, Deutsch describes knowledge as abstract (non-physical) yet real (2011, pp. 74, 95). Like Popper, Deutsch views knowledge as an abstract entity, comparable to numbers. Knowledge does not need to be physically instantiated but still has the power to act upon the physical world. One of Deutsch's definitions of knowledge is "information with causal power" (Ted Audio Collective, 2021). This broad definition encompasses more than the traditional conception of knowledge. For instance, if information with causal power constitutes knowledge, then the information encoded in DNA also qualifies as knowledge. According to Deutsch, knowledge is something that causes itself to be replicated (2011, p. 114). The knowledge encoded in DNA has been created through natural selection and is classified as non-explanatory knowledge. While it evolves to solve specific problems, such as adapting to an ecological niche, it is not consciously created and does not inherently provide an account of what the world is like. By contrast, humans possess a second type of knowledge: explanatory knowledge (Deutsch, 2011, p. 105).

2.2.3. How People Learn: The Primacy of Problems

One of the most relevant problems in education involves the question of how students learn. Understanding what learning is and how it occurs allows educational institutions, such as curricula, to adapt to providing students with an environment conducive to learning. Beyond institutional adaptation, it is equally important for educators and students to understand how learning takes place. Fortunately, explaining the growth of knowledge is a key competence of Popperian epistemology, and its learning theory can be used to gain deeper insights into the structure of learning.

What Learning Is

Learning, according to Popperian epistemology, encompasses three phases, which will be elaborated on in this section. Popper's theory of learning can be considered universally applicable. It is universal in the sense that it applies equally to all kinds of knowledge, including knowledge of facts or theories, skills, and other types of understanding.

Gilbert Ryle famously made a distinction between skills ("knowing how") and knowledge ("knowing that") (2009 [1949]). He rightly pointed out that both types of knowledge share the similarity of being dependent on learning (Ryle, 2009 [1949], p. 17). However, this influential distinction can be regarded as largely irrelevant to the method of learning from a Popperian perspective. This irrelevance stems from the universality of Popperian learning theory, which posits a logical structure that essentially mirrors problem-solving (Chitpin, 2016).

Solving a problem in the Popperian framework consists of three phases. The first phase involves the emergence of a problem. This problem may be theoretical, such as understanding a piece of music theory, or practical, like learning to play barre chords on the guitar. The classification of problems is somewhat arbitrary and should only be considered for convenience and orientation. Learning can thus be seen as a process of theory formation, where, once a problem emerges, one attempts to solve it by guessing possible solutions—this represents the second phase of problem-solving (UQ, p. 44f.). The third phase involves improving the hypothesized solution by seeking and correcting errors.

In the Popperian framework, problem-solving rests on the distinction between two types of thinking: dogmatic and critical, both of which are intricately connected (UQ, p. 52f.). Regarding the significance of critical thinking, Popper emphasizes that “error correction is the most important method in technology and learning in general. (...) One rightly speaks of the trial-and-error method, but this understates the importance of mistakes or errors—of the erroneous trial” (ALiP, p. 100). Errors, therefore, become the most valuable source of learning. It becomes evident that the demonization of errors should be rejected, as learning fundamentally involves learning from mistakes. Critically, learning entails selecting from possible solutions to a problem.

With respect to different types of learning, Popper identifies three: discovery learning, learning by imitation, and learning by habit formation. He writes:

> There are three senses of the verb ' to learn' which have been insufficiently distinguished by learning theorists: 'to discover'; 'to imitate'; 'to make habitual'. All three may be regarded as forms of discovery, and all three operate with trial-and-error methods which contain a (not too important and usually much overrated) element of chance. 'To make habitual' contains a minimum of discovery-but it clears the decks for further discovery; and its apparently repetitive character is misleading. In all these different ways of learning or of acquiring or producing knowledge the method is Darwinian rather than Lamarckian: it is selection rather than instruction by repetition. (OK, p. 149)

The key insight is that all types of learning follow the same schema and adhere to the same epistemology. All forms of learning are instances of problem-solving achieved through conjecture and criticism. This insight is crucial for educational theories, as one fundamental learning process can take various forms, all of which can be harnessed under the right conditions.

Preconditions for Learning

It seems that the most important precondition for learning is the learner’s autonomy to pursue problems that they deem interesting. Self-directed experience opens the door to problems, which provide the environment in which creative thinking can arise. Both the generation of explanations and the elimination of errors are highly creative endeavors. Regarding creativity in the learning process, Popper writes that:

> it seems to me that what is essential to “creative” or “inventive” thinking is a combination of intense interest in some problem (and thus a readiness to try again and again) with highly critical thinking; with a readiness to attack even those presuppositions which for less critical thought determine the limits of the range from which trials (conjectures) are selected; with an imaginative freedom that allows us to see so far unsuspected sources of error: possible prejudices in need of critical examination. (UQ, p. 48)

If the freedom to experience and select interesting problems constitutes the precondition for genuine learning, then conversely, external direction that prevents the learner from pursuing such problems inhibits creativity. This is precisely Deutsch's argument, as he cautions that coercion stifles creative thinking and therefore advocates for education free of coercion (1994).

Problem Solving

As previously mentioned, the starting point of the learning process is always signified by the emergence of a problem. A problem should not be understood as something that causes stress or pain but rather as something solvable that sparks curiosity and prompts investigation. The quest for knowledge begins with problems—not theories or observations alone. Every organism finds itself situated in a particular problem situation, shaped by its own horizon of expectations (OK, p. 359). This includes the problem solver's perspective, focus, and the priority they assign to conflicting ideas. Indeed, problems mark the starting point of the learning process.

David Deutsch argues that "conflicting ideas in a broader sense are the occasion for all rational thought and inquiry. I shall call a situation in which we experience conflicting ideas a problem. Solving a problem means creating an explanation that does not have the conflict" (2011, p. 17). For Popper, problem-solving fundamentally involves identifying and resolving contradictions (CaR, p. 432).

A trivial but illustrative example of a problem in the Popperian sense is the following:

- P1: All tables have four legs.
- P2: This object (functioning as a table) only has two legs.
- C: This object (functioning as a table) is not a table.

The problem situation here arises from the conflict between our existing assumption—P1: "All tables have four legs"—and the observation of a two-legged object functioning as a table (P2). According to Popper, learning begins with a problem, specifically when we encounter something that contradicts our existing expectations or theories.

In this case, our theory about tables is challenged by an observation that does not fit our model. This creates a conflict between expectation and observation, providing an opportunity for error correction. In Popper's terms, this constitutes a refutation of the

theory that “all tables have four legs,” as a single counterexample suffices to falsify a universal claim. The observation motivates a revision of our original theory.

This marks the beginning of the critical phase: error elimination. We must re-examine our theory to identify the source of the error. Our observation of the two-legged table, combined with additional evidence (e.g., consulting a friend who informs us that tables can have one leg), forces us to revise our theory. We now understand that not all tables have four legs, leading to a new hypothesis: “Tables can have different numbers of legs and still function as tables.”

However, problem-solving is open-ended and often leads to deeper questions. Once the initial problem is solved, new and more complex problems may emerge. For instance, we might now wonder: What qualifies an object as a “well-built” table, regardless of the number of legs? This new problem extends beyond the simple issue of leg count, touching upon principles of structure and function, and presents further challenges for investigation.

Of course, new problems do not necessarily follow from solving old ones, and what is recognized as an interesting problem remains up to the learner. After all, we may decide that we have thought enough about tables for now after successfully solving the four-leg problem.

Popper introduces his problem-solving schema, which consists of four elements and three steps in-between, in *Objective Knowledge* (OK, p. 119). First, one identifies a problem (P1). The problem solver then formulates a tentative theory (TT), or tentative solution, by means of creativity—it is mere guesswork. Next, in a crucial step, errors are identified and unsuccessful attempts at a solution are eliminated (EE). Error elimination can be achieved by criticizing one’s own theory, implementing the solution and failing, or by any other method in which the solution clashes with reality.

This elimination procedure leads to a second problem (P2). The new problem may be a modified version of the first or an entirely different issue. During the elimination process, it may also become apparent that the initial problem was not the correct

problem to address in the first place. This schema represents a broadly applicable model of problem-solving and underscores the essential steps in the learning process.

P1 → TT → EE →P2

P1 = Problem, TT = Tentative Theory, EE = Error Elimination, P2 = New Problem

Starting Point

The starting point does not matter—progress is made through criticism (Popper, *OK*, p. 129). The sources of knowledge are not, in themselves, the most important aspect of knowledge creation. Indeed, Popper stated that "all sources are welcome" (*CaR*, p. 36). Whether one begins conjecturing solutions to a problem using common sense, a form of traditional knowledge, or a mere hunch, the critical factor in problem-solving—and thus in knowledge creation—is criticism.

The significance of criticism in knowledge creation, as Popper explains, is that,

> we can learn from our mistakes. This fundamental insight is, indeed, the basis of all epistemology and methodology; for it gives us a hint how to learn more systematically, how to advance more quickly (not necessarily in the interests of technology: for each individual seeker after truth, the problem of how to hasten one's advance is most urgent). This hint, very simply, is that *we must search for our mistakes*—or in other words, that *we must try to criticize our theories*. Criticism, it seems, is the only way we have of detecting our mistakes, and of learning from them in a systematic way. (OS, p. 492)

This quote truly captures the essence of Popperian problem-solving. To successfully solve a problem, attempted solutions must be subjected to criticism. These are the key components of problem-solving: the problem itself, proposed solutions, and the elimination of error. For Popper, error elimination is a unifying process aimed at resolving conflicts by reconciling contradictions. He writes that,

> criticism invariably consists in pointing out some contradiction; either a contradiction within the theory criticized, or a contradiction between the theory and another theory which we have some reason to accept, or a contradiction between the theory and certain facts—or more precisely, between the theory and certain statements of fact. Criticism is, in a very important sense, the main motive force of any intellectual development. Without contradictions, without criticism, there would be no rational motive for changing our theories: there would be no intellectual progress. (CaR, p. 424f)

It is reasonable to assume that, in the Popperian theory of learning, errors are among the most valuable sources of knowledge. The search for errors and their subsequent correction serve as the driving force behind progress in learning. However, prejudicial views on errors often instill fear in learners by portraying errors as signs of failure rather

than as a natural and essential part of knowledge creation. Such misconceptions, which demonize errors, are also present in science. Popper highlights this issue when he argues:

> Refutations have often been regarded as establishing the failure of a scientist, or at least his theory. It should be stressed that this is an inductivist error. Every refutation should be regarded as a great success; not nearly a success of the scientist reviewed the theory, but also of the scientist who created the refuted theory, and who thus in the first instance suggested, if only indirectly, the refuting experiment (CaR, p.329).

In summary, the specific starting point of a problem-solving process is not crucial. Whether the starting point is a particular theory or an intuition, the key lies in the effort to eliminate errors and move beyond the initial position. For Popperians, intellectual progress arises from a critical attitude that seeks out and resolves contradictions in our theories..

Explanations

A fundamentally important aspect of problem-solving is the creation of good explanations. Simply trying something until it works, such as mimicking another person's movements, does not necessarily result in the creation of knowledge; it depends on whether an explanation has been generated. To truly understand why and how something works requires an explanation.

In learning, genuine problem-solving is hindered when students are not allowed to create explanations—for instance, when they are handed answers to problems they have not asked for (*cf.* UQ, p. 40). Worse, students often fail to recognize the problem that the teacher's provided answer is meant to address. To explain, one must engage creatively, which makes the creation of a learning environment that fosters creativity a priority for educational institutions. This involves accepting errors as learning opportunities and allowing students the freedom to explore possible solutions to problems without fear—whether verbal or non-verbal—of disapproval or disappointment from educators.

To further illustrate the relationship between knowledge and explanation, consider Deutsch's comment:

> If I want to explain something like, "How come the stars don't fall down?" I can easily generate 60 explanations an hour and not stop, and say that the angels are holding them up, or they are really just holes in the firmament. Or I can say, "They are falling down and we better take cover soon." Whereas, coming up with an explanation that contains knowledge—an explanation that's better than just making stuff up—requires creativity and experimentation and interpretation, and so on. As Popper says, knowledge is hard to come by. Because it's hard to come by, it's also hard to change once we've got it. (Ravikant, 2023a)

Deutsch adds that “the good explanation is hard to vary. It’s hard to vary because it was hard to come by. It is hard to come by because the easy ones don’t explain much” (Ravikant 2023a). This an extension of the Popperian maxim that genuine knowledge is “hard to come by” (CaR, p. 502).

Criteria for Good Explanations

If creating good explanations is essential to learning, then one ought to ask which criteria distinguish good explanations from bad explanations. In Deutsch’s account, an explanation can be described as a “statement of what is there, what it does, and how and why” (2011, p. 30). This description leads one to ask what qualifies such statements as better than others. Deutsch expands on the Popperian notion of theories and makes the quest for good explanations the center of knowledge creation. Deutsch's comment about better explanations being hard to vary gives a clue to the most important criterion of good explanations: invariability, or the idea that the fewer moving parts an explanation contains, which in turn need further explanation, the better.

For Popper, the explanatory power of a theory means that it is able to solve more problems and explain the given more precisely than its rival theories (CaR, p. 259f). As a result, good explanations allow for precise predictions. Furthermore, the more precise a theory is, the less probable it is to be true because the more the theory prohibits, the more it allows for independent tests and the higher its risk for falsification (CaR, p. 313, p. 43). Good explanations are the result of “bold conjectures” that seek to explain the known with the unknown (CaR, p. 235).

In contrast to good explanations, bad explanations are easy to vary. It is not sufficient that theories are testable and predictive, not least because bad explanations can be testable and predictive. Being easy to vary, i.e., having a multitude of parts that do not play an instrumental role, a bad explanation can be used to explain anything and thereby tends to immunize itself against criticism. For instance, to explain a particular plane crash over a particular mountain with the theory that it was “God’s will” is a quintessentially bad explanation. The “God’s will” theory can be used to explain anything and thereby, strictly, explains nothing. Another illustrative example of a bad explanation is the explanation of the seasons with the ancient Greek myth of Hades

and Persephone when compared to the good explanation of the axis tilt theory of the seasons (Deutsch, 2011, p. 19f). Deutsch summarizes the axis tilt theory as follows:

> The Earth's axis of rotation is tilted relative to the plane of its orbit around the sun. Hence for half of each year the northern hemisphere is tilted towards the sun while „he southern hemisphere is tilted away, and for the other half it is the other way around. Whenever the sun's rays are falling vertically in one hemisphere (thus providing more heat per unit area of the surface) they are falling obliquely in the other (thus providing less). (2011, p. 23f.)

This theory is highly invariable because every part plays a functional role. It is testable, predictive, and has reach. According to the criteria for a good explanation in Deutsch's Neo-Popperian epistemology, the axis tilt theory is preferable to theories with less explanatory power, mainly because it is hard to vary. In summary, the problem-solving process, representative of human knowledge creation, always involves explanatory theories. In solving a problem, which essentially is a conflict between ideas, one creates explanations that can resolve the conflict while being hard to vary.

Figure 7

Criteria for explanations

2.3. Educational Theories

Over the past centuries, numerous educational theories (ETs) have been proposed. Each theory, as it relates to learning, inherently includes an epistemological stance. This section surveys a selection of ETs before presenting Popperian learning theories. Examining these learning theories will inform the Popperian critique of epistemology in the final section.

2.3.1. Popperian Educational Theories

Although Popper briefly worked as a teacher in Vienna, he rarely wrote directly about education. One of the few references to education in his writings appears in his autobiography, where he states: “I dreamt of one day founding a school in which no unwanted answers to unasked questions would have to be listened to; in which one did not study for the sake of passing examinations” (UQ, p. 40). Additionally, in the second volume of *The Open Society*, Popper advocates for the following maxim to guide the educational system:

> ‘Do no harm’ (and, therefore, ‘give the young what they most urgently need, in order to become independent of us, and to be able to choose for themselves’) would be a very worthy aim for our educational system, and one whose realization is somewhat remote, even though it sounds modest. (OS II, p. 481)

By this, Popper means that teachers should not try to form their students by shaping them according to certain “higher” values but should instead point towards such values and try to stimulate the interest of their students (*cf.* OS II, 480f). By “harming students,” Popper broadly refers to the coercion of students by the educational system and its failure to treat them as individuals and subjects rather than objects or vessels to be filled. Still, Popper left the field of educational theory largely untouched in his writing, although his epistemology and theory of learning provide theorists with the necessary tools to develop his epistemological ideas into a coherent theory of education.

Popperian epistemology has been adopted by educational theorists, notably Tyrell Burgess in the 1970s and 1980s. Richard Bailey and Joanna Swann represent more contemporary theorists influenced by Popper’s learning theory. Popperian educational theories tend to extend Popper’s epistemology into the field of schooling in a fairly straightforward manner. On the one hand, such theories have the advantage of utilizing the critical arguments laid out by Popperian epistemology against rival theories influenced by mistaken theories of knowledge, such as empiricist-inspired learning

theories. On the other hand, according to Swann (1999), Popperian educational theories present a universally applicable explanatory framework for teachers, emphasizing the open-endedness and the significance of autonomous problem-solving in the learning process.

Popperian educational theorists critique other learning theories by emphasizing the incompatibility of Popper's logical learning model with prevailing views of knowledge and learning. Burgess (1977) criticized what he viewed as the traditional view of knowledge in his time. His main critiques pertain to the empiricist verificationism inherent in the traditional "view of knowledge, and thus of education, which is authoritarian, cumulative, exclusive and arcane" (1977, p. 127). In contrast to the dominant educational theories, Burgess articulates his view on education, arguing that:

> education […] cannot mean an ever-deeper initiation into the mysteries of a subject, nor research the gradual extension of a body of knowledge. If it is this, then it cannot serve anybody except academics. If education is to mean increasing mastery of their circumstances for most people, it must be differently based. (1977, p. 127)

Popperian theorists like Burgess critique the educational system's reliance on inductivist principles, including the bucket theory of mind. He contends that induction and other empiricist ideas shape educational institutions through their organizing principles:

> It appears to me, however, that the organization and practice of higher education, both academically and institutionally, rests upon an implicit acceptance of induction; in other words upon a fallacy. It is impossible to speak, as academics do, of the preservation, extension and dissemination of knowledge unless one has in mind the gradual accumulation of certainties. The whole idea of the preservation of knowledge is alien to scientific method: what we should be seeking to do is destroy our present theories. (Burgess 1977, p. 131)

Popperian learning theorists argue that the bucket theory of mind reflects an implicit acceptance of empiricist inductivist ideas. Examples of this include the mistaken view of learners as receivers of knowledge (Bailey, 2000, p. 77). Moreover, according to this view, laws and regularities in the cognitive system are established by repeated observation or experience, and thus knowledge grows from receiving information external to the learner. It is hardly surprising, then, that grammar drills and rule-based learning are still practiced forms of teaching students, based on the idea that frequent repetitions lead to associations of ideas and therefore the formation of knowledge.

In further distinction from more classical theories of learning, Popperian educational theory firmly rejects the notion of passive learning (Swann, 1999). One reason for this is Popper's argument that all observation occurs in light of a certain problem situation

and is already guided by expectations. Another issue that Popperian educational theorists highlight in popular learning theories is the impossibility of instruction from "without," which can be thought of as information consisting of discrete elements being transferred from a source to the mind of the learner (Bailey, 2000, p. 74). Associated with such a view of learning are images like the brain functioning as a sponge, soaking up information that is then stored within (Swann, 2007). Furthermore, knowledge growth cannot be reduced to the "accumulation of certainties" or an expanding collection of verified facts (Burgess, 1977, p. 131).

An Alternative Educational Framework

In designing an educational framework based on Popperian learning, it is unsurprising that demands for certainty, justification, and verification are rejected. Bailey argues that:

> Popper's theory of learning stands in stark contrast to traditional empiricist theories of learning through induction. Rather than learning through a gradual process of observation, induction and association, Popper suggested that the learner jumps to conclusions. She makes unwarranted generalisations about the world that are tested against the environment. Learning occurs through a process of trial and error-elimination. (2000, p. 87)

Because of the creative and constructive nature of knowledge and the trial-and-error method of learning, in Popperian educational theory, the individual learner is the focal point. Swann, for instance, highlights the need to support the individual student in order to achieve learner autonomy as the most valuable educational goal (2012, p. 186). With respect to a concrete model of learning, Burgess (1977), Bailey (2000), and Swann (1999) all advocate for the implementation of the Popperian problem-solving model, which has been presented in section 2 and is reviewed here:

Problem (P1) → Tentative theory (TT) → Error elimination (EE) → Problem 2 (P2)
(OK, p. 126)

In brief, it rejects observation as a starting point, arguing that observation is always guided by expectations and problems. Problems act as the starting point for knowledge creation, arising from critical imagination. Learners, over the course of solving problems, explore their environments by guessing regularities and invariants and trying to apply these guesses to the environment (Bailey, 2000, p. 88). It must be noted here that, for Swann, the social and physical context in which learning takes place fulfills a selecting role. She argues, "the effect of the social and physical environment is purely

one of selection: the environment serves merely to challenge the learner's expectations (implicit and explicit) and potentially eliminate them" (Swann, 2007). The general picture of learning is that "human beings are constantly, actively solving the plethora of problems presented by life, and they do this through a process of action and selection, of trial and error-elimination" (Bailey, 2000, p. 101). Following Burgess' (1986, p. 67) differentiation of philosophical, scientific, engineering, formal, and aesthetic problems, Swann (1999) emphasizes the distinction between two major types of problems, most notably between practical problems and theoretical problems. Practical problems, unlike theoretical problems such as scientific or logical problems, need something in addition to the formulation of a theory – they require action to be taken (Swann, 1999).

In order to conceptualize learning more closely, Burgess draws on the Popperian distinction of three types of learning: learning by imitation, learning by repetition, and, most importantly, learning by discovery (1977, p. 128). As previously pointed out, all three types of learning follow the same method of learning, namely by trial and error. This may easily be overlooked in the case of learning by repetition. According to Bailey, repetition is not a learning mechanism itself but a way to delegate understood concepts to lower consciousness levels, freeing attention (2000, p. 93). By this, the empiricist stance is reverted, according to Bailey, as "rather than make discoveries conscious, they actually eliminate them as far as possible from consciousness" (2000, p. 93). The trial-and-error process of learning clearly is the key method of knowledge creation, but it requires a grasp of the problem at hand to start. Burgess states that,

> the beginning of an inquiry is not the attempt to solve a problem (the tentative theory comes second, not first): it is the problem itself, and it is important to work as hard as possible on the formulation of problems before searching for solutions. This is because success in the latter often depends upon success in the former. An enormous amount of time and energy is wasted in the world by people who jump straight into solutions and concentrate upon the difficulties of these — without pausing to consider whether they are apt for the problem formulated or even without formulating a problem at all. (It is also misleading to talk of 'identifying' problems, as if the problems were sitting there waiting for us. They are not. Problem-formulation is a creative activity. (1977, p. 129)

Of course, the formulation of a problem is itself subject to conjecture and criticism, and one can make errors in even understanding what the problem is. Hence, it should not be surprising when students claim that they "don't understand anything," as sometimes the problem situation is not even clear, which presents a chief obstacle to learning. This leads to another important point of consensus in Popperian educational theory,

namely the position that instruction from without the individual learner is impossible (Bailey, 2000, p. 74). Instruction, in the sense that knowledge can be received from the outside world, like in the bucket metaphor of the mind, is incompatible with the Popperian picture of the mind and learning. All learning requires active individual construction, as there are always expectations involved that clash with the environment, through which knowledge is created by critical imagination. However, Bailey differentiates between instruction for learning and instruction as a method of teaching. As pointed out, instruction from without is impossible as a learning mechanism. But according to Bailey, it can be valuable for teaching. He argues,

> children do not learn by passively cumulating information from the outside world, they actively interpret and construct their knowledge. Children can learn from traditional sources as much as they can from first-hand experience; in neither case does information just flood in, it is selected and filtered by the learner. To reject instructional styles of teaching is nonsensical, for it ignores perhaps the most valuable sources of knowledge available, tradition and the contents of World 3. (2000, p. 103)

Thus, it can be concluded that learning always involves problems in the form of expectations that are disappointed or other conflicts between theories. Problems capture the learner's attention, prompting imaginative criticism and conjectured solutions for resolution. This sharply contrasts with theories that view learning as receiving verified facts, associating ideas, or building knowledge cumulatively.

2.3.2. Educational Theories Incompatible with Popperian Epistemology

From the point of view of Popperian learning theory, some popular learning theories are informed by inadequate epistemology and therefore cannot be effective in conceptualizing the learning process. Unsurprisingly, those inadequate learning theories are either empiricist and promote some form of inductivism, or relativist constructivism, which are subjected to the myth of the framework. This often results in coercive educational practices that, according to Popperians, hinder the application of critical imagination. What follows is a brief survey and critique of a selection of prominent theoretical stances that form the basis of various popular educational theories today.

Empiricist Learning Theories

Although few educators identify as behaviorists today, behaviorist practices like drills, rote learning, and reliance on repetition remain prevalent. The epistemic views underlying these activities are representative of empiricist ideas such as the possibility of passive learning and learning by association. Also included in such an educational stance is the misunderstanding that learning can be conceived as an accumulation of verified knowledge (or facts). Of course, such views of learning are firmly rejected not only by proponents of Popperian learning theories but by various modern educational positions. Nonetheless, Popperian learning theory provides a comprehensive critique of empiricism in the educational context—a fact that is mentioned here for completeness's sake but not elaborated further since the discussion of the bucket theory of mind already provides a clear refutation of popular empiricist assumptions.

Critical Pedagogy

Apart from empiricist pedagogies, post-Marxist learning theories inspired by Paulo Freire's work and commonly known under the label "critical pedagogy" are also fundamentally at odds with Popperian learning theory. In line with Marxist theory, Freire views human thought as fundamentally conditioned by material conditions (Freire, 2000, p. 45). This seems to be indicative of the epistemic stances of critical pedagogy as a whole, which tends to draw a fundamental distinction between oppressors, who hold, cement, and increase power through power structures embedded in social institutions, and the subjected people, who need to be liberated. Down and Steinberg write about this type of educational stance that "at the root of critical pedagogy […] is the willingness to confront injustices and relations of power which hold them in place. This requires a fundamental transformation in the ways in which knowledge is produced and legitimated and by whom" (2020, p. xliii). Besides this focus on power structures and the oppressor vs. oppressed dialectic, critical pedagogy is also marked by a decidedly anticapitalistic attitude, viewing capitalism as "the root of domination" (Darder, p. 570).

At the heart of many critical pedagogies lies what might be called the "postmodern knowledge principle," which views objective knowledge as unattainable or illusory and includes a "commitment to cultural constructivism" (Pluckrose & Lindsay, 2021, p. 31). This failure to appreciate knowledge for what it is can be illustrated by two Popperian points of criticism. First, critical pedagogy treats knowledge as mere narratives or

discourses. It is endemic to a relativist notion that truth is a mere instrument for exercising, retaining, and increasing power. This attitude, of course, represents a modern form of the myth of the framework critiqued by Popper. The focus shifts to the sources and origins of knowledge claims, as objective truth is either deemed nonexistent or unreachable due to our specific frameworks. It itself gives an authoritarian answer to what is to be learned, namely their own versions of "humaneness" and "social justice" in the form of counter-narratives to what is construed as the dominant discourse. Another main flaw of critical pedagogies is their dogmatic immunization from criticism (relativism) while claiming the label "critical" for themselves, albeit with a peculiarly narrow focus on an oppressor-oppressed dialectic. This is illustrated by Steinberg & Down's characterization of the "criticality" of critical thinking, arguing that "This spirit of criticality seeks to comprehend diverse forms of oppression including class, race, gender, sexual, cultural, religious, colonial and ability-related concerns" (Steinberg & Down, 2020, xliv).

Radical Constructivism

Popperian learning theory clearly shares some features with forms of constructivism. However, Swann (2012) points out that it is incompatible with versions of radical constructivism, especially as formulated by Ernst von Glasersfeld. Swann states that she would regard Popper's theory of learning as a form of radical constructivism if it weren't for the school of radical constructivism already claiming that label (Swann, 2012, p. 59). Indeed, there are undoubtedly shared positions between constructivist educational theory and Popperian learning theory. Most notably, both theories assert that knowledge is actively constructed by the learner rather than passively received. This leads both schools to firmly reject the possibility of passive learning and "received knowledge" from an external source. Learning is inherently individualized, with each student acquiring knowledge in unique ways.

Apart from these similarities, some radical constructivist positions stand in stark contrast to fundamental Popperian positions, such as the rejection of truth as correspondence with reality and the embrace of a subjectivist account of knowledge. The first and most consequential difference between Popperian learning theory and radical constructivism is the latter's rejection of the possibility of approximating truth. This is because radical constructivism, as championed by von Glasersfeld, rejects the possibility of attaining knowledge of the external world that corresponds with the facts.

He claims that, arguably, “the skeptics have formulated logically irrefutable arguments showing that if true knowledge is to represent a real world, it could not be attained” (2005, p. 3). It thus becomes clear that radical constructivism treats knowledge as incapable of telling us anything about reality as it actually is. Von Glasersfeld rests his conception of knowledge on the Piagetian understanding of adaptation and frames knowledge “as a mapping of actions and concept operations that had proven viable in the knowing subject’s experience” (2005, p. 4). He thus explicitly replaces the correspondence theory of truth, which claims knowledge to correspond with external reality, with the notion of viability in light of an organism’s experience. Knowledge, therefore, has become “uninhibitedly instrumentalist” in the sense that “it [radical constructivism, note M.L.] replaces the notion of ‘truth’ (as true representation of an independent reality) with the notion of ‘viability’ within the subject’s experiential world” (1995, p. 22). This means that radical constructivism must result in an extreme form of epistemological relativism since knowledge does not have a truth content but only represents a tool.

Popper points out that

> Instruments, even theories *in so far as they are instruments*, cannot be refuted. The instrumentalist interpretation will therefore be unable to account for real tests, which are attempted refutations, and will not get beyond the assertion that *different theories have different ranges of application*. But then it cannot possibly account for scientific progress. (CaR, p. 151f.)

Indeed, radical constructivism does not even pretend to make truth claims, as von Glasersfeld states “that it would be misguided to ask whether radical constructivism is true or false, for it is intended, not as a metaphysical conjecture, but as a conceptual tool whose value can be gauged only by using it” (1995, p. 22).

Another related reason why Popperian learning theory must reject radical constructivism is that radical constructivism sees knowledge as inexorably bound to one’s experiences. Von Glasersfeld argues that “actions take place in an environment and are grounded in and directed at objects that constitute the organism’s experiential world, not things in themselves that have an independent existence” (2005, p. 4). In Popperian terms, this is a clear case of a school of thought preferring subjective knowledge over objective knowledge and even rejecting the latter. This radical constructivist view rejects objective knowledge by conflating truth with certainty; a misconception shared by postmodernist thinkers, as pointed out by Swann (2012, p.

60). The fact that there is no truth criterion that can provide certainty in relation to the truth content of a knowledge claim does not mean that the existence or indeed the attainability of true knowledge can be rejected.

2.4. Popperian Epistemology and the Austrian AHS Curriculum

In the first part of this work, the curricular epistemology has been examined with a focus on the conceptions of knowledge, learning, and teaching. This segment builds on these concepts to achieve two primary purposes. The first aim is to criticize epistemic assumptions in the curriculum that seem problematic from a Popperian viewpoint, such as the lack of a coherent theory of knowledge. The second aim is the elaboration and modification of relevant principles and ideas that are either already compatible with Popperian epistemology or could benefit from a deeper understanding of the Popperian view of problem-solving and its requirements.

2.4.1. Curricular Epistemology: Knowledge and Learning

In this section, the curricular conceptions of knowledge and learning will be reviewed, and the competence schema will be outlined.

Knowledge

Knowledge, from the curricular perspective, is entailed by competence. Competence is understood as something that enables one to successfully solve certain problems, or the disposition to solve certain problems successfully. In addition to knowledge, there are motivational and social aspects to be considered. Furthermore, this output-oriented concept of competence is the result of a systematic learning process, which can be imagined as a sequence of acquiring building blocks of knowledge. The acquisition of competence is realized through cumulative problem-solving in accordance with clearly specified learning goals.

Competence

Within the curriculum, there is a general competence description schema, which will be briefly examined with the help of specific examples. Typically, competence descriptions within the schema take the form of can-do statements. Note that at the upper secondary level, can-do statements are not made explicit, in contrast to the lower secondary level. The can-do statement specifies and links the learners to an operator and a specific learning goal. The schema looks as follows:

The **students** + **can** + **operator** (acc. to Blooms revised taxonomy) + **content specification**

The same basic schema applies to both the lower and upper secondary levels, as illustrated with the following two examples from different subjects. The first example is taken from the subject-specific curriculum for 1st-grade Mathematics: “Variables and functions”:

The students **can**
- **set up** and **interpret** **simple terms, equations** and **formulas**
- **find solutions** to **simple equations**

The second example is representative of upper secondary competence descriptions. At the upper secondary level, descriptions may omit the “can-do” formulation. However, upper secondary competence descriptions generally include an implied can-do statement. This example comes from the 7th-grade curriculum for the first living language under “Reading”:

- **search for information** in **longer texts**, including literary texts, on familiar topics
- **search** and **collate information** from **different texts**
- **can** **recognize** **the main conclusions in clearly written argumentative texts**

The concept of knowledge, as inferred from the curriculum, suggests that students construct knowledge through training in specific competences. Although the curriculum demands exercises to be “meaningful beyond the classroom” (p. 13), it seems that the development of competence is intended to happen over the course of repeated practice, including the repetition of exercises and rote learning. The schema illustrates cognitive abilities and skills representing the intended educational outcome and, at the same time, specifies a context in which these skills ought to be successfully applied, as indicated by the can-do statement. In summary, and in line with Weinert (2001), competences are dispositions enabling individuals to perform tasks successfully in specific contexts. As shown by the competence schema, the intended educational

outcomes with respect to the individual subjects clearly are the ability to apply certain cognitive operations successfully, therefore placing the emphasis on measurable uses of skills rather than aiming towards knowledge as contained in explanatory theories.

Apart from knowledge itself the curricular conception of learning is formulated as

> an active process in which young people are enabled to apply their knowledge and skills in groups to solve problems. The ability to work in a team is just as important as creativity in order to come up with new solutions and the ability to take a critical look at one's own problem solutions from a distance. (Austrian AHS Curriculum, 2023, p. 9)

This definition highlights some of the main features of the learning theory of competence orientation, which shares some deep points of agreement with Popperian learning theory. First, it highlights learning as an active process involving problems and creativity applied in the search for solutions. Second, critical thinking with respect to one's own solutions is mentioned as a key ability in the learning process. Another key passage with respect to learning can be found in the discussion about the aims of the upper secondary level:

> One of the school's central tasks in developing subject-related skills is the transmission (Vermittlung) of well-founded knowledge. In the sense of lifelong learning, pupils should be enabled and encouraged to acquire knowledge independently and actively, but also to critically examine the available knowledge. (p. 10)

A noteworthy point here is that the curriculum explicitly claims knowledge to be a part of subject-specific competence. Again, in line with Popperian learning theory, criticism with respect to the learner's knowledge is emphasized. However, this quote reveals a divergence between the curricular and Popperian conceptions of learning, particularly in the idea of transmitting "well-founded" knowledge.

2.4.2. Criticism of Curricular Epistemology

The problems with the curricular epistemology can be broadly categorized into general points about the document and specific points pertaining to knowledge and learning. The following discussion highlights some of the most significant points.

In general, the AHS curriculum, as a critical document of the Austrian education system, can be criticized for lacking scientific standards, particularly in its transparency regarding underlying theories. It is not clear how the didactic models mentioned, like the 4K-Model and reflexive pedagogy, have fed into the didactic concepts of competence, nor which aspects are emphasized and why such theories have been chosen. This lack of transparency presents a real obstacle to criticism and thereby discourages attempts at improvement. A related problem is that the AHS curriculum lacks a clear understanding of knowledge, as no theory is explicitly referred to. Its epistemological assumptions, mainly congruences with constructivism, can be identified but have to be inferred from sections 1–4 of the curriculum. The curriculum would certainly benefit from improved transparency and clear communication with respect to the science behind its inception, especially since it prescribes the mandatory educational goals of an entire form of schooling.

Criticism of the Epistemology of Competence Orientation

Firstly, it can be argued that in the current competence model, knowledge is viewed predominantly from an instrumentalist point of view, as something enabling the learner to do something. The problem with this educational form of instrumentalism is, as has been mentioned earlier, that it degrades knowledge to the status of a tool. In the spirit of instrumentalism, knowledge is reduced to a means of acquiring or enhancing competences, often framed as pre-vocational training. However, by focusing on the instrumental view of knowledge, the goal of approximating truth and forming a better understanding of the world is entirely neglected. Even worse, a key component of learning, namely seeking good explanations, is not even mentioned. The competence model, as it is currently informing the curricular epistemology, does not seem to be interested in having students formulate theories about the world or criticize existing theories.

Furthermore, in the curriculum, remnants of the bucket theory of knowledge (knowledge and competences understood as discrete units) can be discerned. In some form, the learners are still treated as vessels to be filled—not by the teacher but by themselves—solving problems and thereby developing competence through repeated instances of training. Over the course of such training, learners should ideally act in a self-directed manner and be able to apply their acquired knowledge in different situations (Austrian AHS Curriculum, 2023, p. 13). Regarding knowledge, the curriculum stresses the systematic and cumulative nature of knowledge as well as its interconnectedness with different areas of knowledge. This conceptualization of knowledge, as organized into disciplines—even if it values interdisciplinarity—inevitably paints a mistaken picture of knowledge by neglecting the problem-based character of human knowledge, which is more akin to an explorable landscape of problems than a web or an ever-growing collection of facts.

With respect to practice, the curriculum states that "students have learning experiences that go beyond the lesson are meaningful" (p. 13). However, it also demands that "learners should understand the demands placed on them, *accept them* and learn to assess themselves, choose suitable approaches and methods to acquire the required professional, personal and social skills and thus find motivation for their work" (Austrian AHS Curriculum, 2023, p. 15, emphasis M.L.). Although practice is supposed to consider and involve learner autonomy, this must happen in agreement with the specifications set by the curriculum, and therefore it falls to the teacher to act as an intermediary, designing problems that convey competences as specified by the curriculum to the learners. This clearly represents a form of instruction from without, which can be illustrated by virtue of the competence schema outlined earlier. This schema prescribes an operator (e.g., analyze) and associates it with a content point (e.g., climate diagrams). It therefore presents students largely with external problems and skills, sometimes excluding the method of learning itself from autonomous problem-solving by the students. Swann (1999) argues that:

> problems cannot be passed from one person to another as if handing over a parcel. This is not to suggest that problems cannot be shared but the problem context has to be shared first. In order for two or more people to share a problem they must, to some degree, experience (at least conceptually) the same kind of mismatch. When teachers give children problems to solve, their relationship is seldom that of equals; generally, the teacher will need to consider how to engage the children in a genuinely educational problem, rather than the problems of "how to please the teacher" and "how to get the result the teacher wants." Of course, children can and do learn while engaged in the process of pleasing their teachers, but it is a mistake to think they are necessarily working on similar problems (or learning only what has been planned).

Exactly in the fact that externally imposed problems generally impede the learning process because they do not allow for learner autonomy, such rigid competence descriptions thereby impede real learning. This is one of the regrettable consequences of the bucket theory of mind, according to which competences as educational products are paramount and trump real learner autonomy. Undoubtedly, there is a coercive and authoritarian element in the curriculum with its centrally planned educational goals that must be adhered to by teachers and reached by learners. To this point, Burgess argues that the learners,

> will not learn better or faster if we parcel up received solutions to problems formulated by others: indeed this is an anti-learning process. Moreover, it inhibits the possibility of progress, because it is always possible that someone will formulate a common problem differently, will propose a different solution or a more effective test. (1977, p. 132f)

This authoritarianism is also explicable by considering the bucket theory of knowledge. It presumes an authority, in this case the curriculum with its planned learning outcomes, rather than the knowledgeable teacher who pours knowledge from her mind into the learners'. However, the shift of authority from the teacher, who now acts more as a moderator and facilitator in her role as enforcer of the curricular goals, nonetheless works against the specified goal of viewing students as individuals and enabling learner autonomy.

Criticism of the Curricular Conception of Learning

Importantly, the epistemic outlook of competence-oriented pedagogy also feeds into its demands for teaching. Learning is claimed to be autonomous and individualized, yet there is no real way for self-direction in the learning process. All students must achieve the same educational outcomes, as outlined in the competence descriptions formulated in the curriculum. Thus, the competence-oriented AHS curriculum, as an output-based document, represents a case of central planning in education. Laws such as SchUG 2024 and SchOG 2024 set expectations for the curriculum, which, in turn, establishes narrow expectations for schools and teachers that must be implemented in schools. Within schools, teachers tend to centrally plan lesson content, structure, and assessment schemes. Subsequently, students are subjected to these plans devised by their teachers.

It follows that there is limited space left for genuine learner autonomy, as every element of the educational institution is expected to execute a predefined plan. However, it should be noted that planning itself is not inherently problematic. The issue lies in the rigidity of the competence descriptions in the curriculum, which fail to consider the open-ended nature of the educational process and lack flexibility to individualize learning. Swann (2011) makes several arguments against objectives-based planning. One of her key points highlights the inability of objectives-based education to account for the open-endedness of real learning, which is predicated on the erroneous belief that predefined goals must be met to achieve educational success.

She advises,

> when advocates of objectives-based planning ask, 'How do you know where you are going if you haven't formulated aims [broad goals] and objectives [targets]?' a valid answer in all but the most mundane situations is, 'You don't — but you can have some idea of where you are (through problem formulation), of where you and others have been (by being aware, where applicable, of previously tested ideas, practices and strategies), and what you are travelling with (a method).' The future, unlike the past, is open; people cannot, with any degree of certainty, know what will take place. (Swann 2011, p. 205)

This principle applies perfectly to the Austrian AHS curriculum, which provides a predefined set of competences—an educational plan that all students, irrespective of their interests, must follow. At most, students decide on their specialization (e.g., languages, science, economics), but they do not have any intra-disciplinary control over the learning process.

Consequently, due to the restricted student autonomy resulting from output-oriented planning, the curriculum seems to fail in meeting its own aspirations of respecting students as individuals and promoting their learning as autonomous and self-directed. This failure also undermines the promotion of lifelong learning. These shortcomings manifest in at least three types of autonomy:

- **Topical autonomy:** The ability to seek, find, and formulate problems that are interesting to students.
- **Autonomy of method:** The freedom to approach problems at their own pace, formulate their own attempts at solutions, and discover errors in both their proposed solutions and those of others.
- **Social autonomy:** The ability to voluntarily associate with other students to solve problems, while also retaining the liberty to solve problems independently.

Regarding topical autonomy, students are, at most, allowed to choose their specializations (e.g., *Realgymnasium*) and elective subjects. However, it must be noted that some subjects, as they are currently conceptualized, are inherently more conducive to allowing for topical autonomy within the current restrictions set by the curricular competence specifications. A prime example is language subjects, which allow for a wide range of communicative situations and are not overly specified in the current curriculum. Regardless, with the restriction of topical autonomy through overly specified learning content, teachers have little leeway to enable students to make choices based on their interests. This lack of choice makes identifying and formulating genuine problems far more difficult and impractical than necessary. Since explanation-seeking and criticism, as the method of problem-solving, characterize learning, pedagogy should aim to create conditions that enable problem-solving, which always begins with an interesting mismatch between expectations and reality.

The next type of autonomy restricted by the competence-oriented paradigm pertains to how students solve particular problems and the role that criticism plays in the process. First, Burgess argues,

> since criticism is of the essence of the method, education must offer opportunities for students to be critical and to use criticism. It cannot, even (indeed especially) for the sake of instruction, ask the students to accept the greater knowledge, experience, and wisdom of the teacher. This implies, […], that it is the students who must take the initiative in planning their own education. There can be little justification for the prior imposition of curricula and syllabuses. Such curricula must necessarily presuppose purposes which may not be the students. (1986, p. 69)

This clearly hints at the necessity of being able to deviate from pre-designed purposes of educational design set by the curriculum or the teacher without punishment. For Deutsch, disobedience is a precondition of creativity (Deutsch, personal communication, June 14, 2024), as deviation from the trodden path allows for doing and thinking things differently. Closely connected to the necessity of criticism is the status of errors in learning. Errors are often penalized and discouraged because they distract from reaching pre-designed learning goals, even though they represent the most important sources of learning. For instance, tests are often designed to minimize errors by requiring students to reproduce entrenched algorithms in a variation of familiar contexts. A common example would be a math test requiring students to apply memorized rules to new numbers or a grammar worksheet focused on using recently learned rules. These kinds of tests are prevalent across most subjects and are designed to ensure faithful knowledge transmission. However, they do little to

encourage learning or problem-solving through error correction, as they inherently discourage mistakes and impede the critical method.

Furthermore, lesson structures are heavily influenced by assessment methods. In subjects relevant to the standardized Matura, the required number of tests per semester largely dictates lesson plans to prepare students for the final exam. As a result, students often “learn” for tests rather than explore ideas. This focus on standardized assessments disregards the open-endedness essential to true learning. Learning is an exploratory process that involves identifying mismatches between expectations and experiences or resolving conflicts between ideas (Swann, 1999). It requires methodological autonomy, enabling students to develop their own solutions and test them in an error-tolerant environment. Only when the fear of making mistakes is removed can errors become accelerators of learning.

The final form of autonomy restricted by the current competence-oriented paradigm is social autonomy. Group work and social learning are frequently mandated, as they are generally perceived as good practice. However, students have diverse social preferences, and these do not always align with enforced group activities. Since each learner is an individual, their preferences for collaboration or independent problem-solving vary. Social preferences may also change depending on the problem at hand. Some students may choose to collaborate with peers on specific problems, while others might prefer tackling issues independently. Forcing group work assumes that all students share the same problem situation, which is often not the case. True social autonomy means allowing students the choice to collaborate or work individually based on their preferences and the nature of the problem

2.4.3. Modifications of the Curricular Epistemology

It seems that Popperian epistemology, and by extension, Popperian educational theory, can help to expand and improve the epistemology embedded in the competence-oriented AHS curriculum by addressing three critical problem areas: providing an explicit theory of knowledge, specifying what students should learn, and outlining how learning works to extend the current competence model.

Knowledge in a New Light

First, Popperian epistemology can offer the curriculum an explanatory theory of knowledge that defends a rational and scientifically informed worldview against relativist and dogmatist forms of irrationalism. At the same time, it aligns with the values emphasized throughout the curriculum, such as fostering student autonomy in learning and encouraging critical reflection. This Popperian theory of knowledge can be briefly summarized as follows:

1. **Common Sense Realism**: Popperian epistemology adheres to the idea that there is an objective world that we are part of and can gain knowledge about.
2. **Truth as Correspondence**: The concept of truth, understood as correspondence with the facts, is a regulative idea that can never be reached with certainty.
3. **Fallibility of Knowledge**: All knowledge is mere opinion or guesswork, containing errors, yet it can correspond more or less closely with reality.
4. **Knowledge Growth**: Knowledge grows by seeking good explanations and correcting errors in tentative theories. It never progresses through attempts to verify hypotheses; only critical engagement with them brings us closer to the truth.
5. **Knowledge as Causal Power**: Following David Deutsch, knowledge can be conceptualized as information with causal power, meaning it has the ability to act on and change the world. Knowledge is not a matter of belief and is never justified because all human knowledge is inherently fallible.
6. **Problem-Based Nature of Knowledge**: Knowledge is created to resolve conflicts of ideas or inconsistencies between expectations and experience. It is embedded in problem situations and aims to solve these problems.

In the Neo-Popperian perspective, humans are seen as universal explainers, capable of abstraction and knowledge creation in ways limited only by the laws of physics. In summary, the most significant contributions of Neo-Popperian philosophy to the curriculum would be the recognition that knowledge is always embedded in problem situations, is created to solve problems, and is never justified or infallible. Instead, knowledge creation relies on the process of conjecture and criticism.

What Is to Be Learned?

The second problem relates to the question of what students are expected to learn. Given the generality of Popperian learning theory, it can modify the competence schema to account for more than the mere instrumental use of knowledge and skills. Furthermore, by respecting education as an open-ended process, a shift in focus from an objectives-based curriculum, which is a consequence of educational central planning, toward alternative conceptions of curricula will be necessary.

An extensive critique of objectives-based educational planning has been offered by Swann (2011). Some of her arguments against this approach point to its failure to account for the openness of the educational process, which cannot be adequately reconciled with predefined outcomes. In the case of the competence descriptions in the AHS curriculum, they are too rigid to allow for exploratory learning to take place. Swann's second argument is that the design of learning objectives often represents a compromise among the designers. She argues:

> When a group convenes to develop policies and/or plans, trying to achieve a consensus about aims often results in the selection of the lowest common denominator of the group's ideas. This is why statements of aims are generally so banal (though they can turn out to be more controversial than their formulators anticipate). (Swann 2011, p. 206)

By implementing the lowest common denominator into objectives-based planning, the curriculum selects for mediocrity in addition to being authoritarian by “denying individuals the right to determine important features of their formal learning,” according to Swann (2011, p. 207). This raises the question of how educational goals can be conceptualized differently. The principal idea regarding what is to be learned is this: Instead of treating knowledge as a canon of answers to questions that students never asked or a collection of abilities to be trained, we should instead view knowledge as an open landscape of explorable problems. This entails three aspects.

First, a shift toward problem orientation must occur, redefining competences as educational outcomes to focus on identifying and exploring problems created by the individual learner. Second, problem orientation also requires the autonomous use of methods, such as conjecture and criticism, to solve problems. This autonomy is enabled by the freedom to explore independently, form conjectures, critique solutions, and engage in critical discussions of problem solutions in the classroom environment. To achieve this, educational institutions face the challenge of creating an environment conducive to open-ended exploration of problems.

All these points lead to the third aspect: the curriculum must make space for choices, allowing for extensive co-constructivity of the learning process, applying to both learners and teachers. In other words, teachers as well as learners need more room to choose problems, social forms, and methods.

Regarding learning and knowledge from a Popperian point of view and taking into account the need for a problem-based paradigm, it can be argued that the curriculum would benefit from extending a narrowly competence-focused pedagogy to a more universalist view capable of accommodating learner autonomy. Furthermore, a problem-based pedagogy, drawing on Popper's problem-solving schema, can account for all kinds of problems and ways of knowledge creation, both practical and purely theoretical. Considering Popperian theory of learning, it is possible and even necessary to see skills and theoretical knowledge as subject to the same epistemology. A possible way to extend the competence-oriented paradigm might be to introduce a sort of meta-competence, namely problem-solving competence, as that which enables problem-solving and thereby the development of competence regardless of the specific learning content. Since Popperian epistemology is universal and lends itself to all forms of human knowledge creation, ranging from learning in purely theoretical fields to practical skill acquisition, the Popperian problem-solving schema already contains the necessary components of problem-solving competence. These components of meta-competence are problem formation and expression, formulating guesses as possible solutions, and criticism, which includes seeking better explanations through finding inconsistencies.

One of the main aspects of Popperian learning theory is the focus on error correction, which constitutes a key aspect of meta-competence. The significance of error correction in learning lies in the fact that “without error correction, all information processing, and hence all knowledge-creation, is necessarily bounded. Error correction is the beginning of infinity” (Deutsch, 2013, p. 140). It is worth mentioning that the curriculum explicitly encourages tolerance for errors and, therefore, emphasizing error correction is compatible with the curriculum in its current form (p. 14).

An initial conceptualization of meta-competence could be structured as follows:

Meta-competence type	**Description**
Problem formulation (P1, P2)	1. Ability to recognize a mismatch between expectation and experience or a conflict between ideas. 2. Ability to express a mismatch between expectation and experience or a conflict between ideas. 3. Ability to manage and prioritize problems and sub-problems.
Conjecture (TT)	1. Ability to formulate one’s guesses/solutions in a manner that they can be subject to criticism 2. Ability to formulate explanations (hard to vary).
Criticism (EE)	1. Ability to probe for inconsistencies. 2. Ability to search for better explanations (harder to vary). 3. Ability to explore the consequences of alternative explanations.

How is Learning to Take Place?

The third problem, besides the conception of knowledge and the question of what should be learned, is the question of how learning is to take place. As previously stated, the curriculum emphasizes that learning is an activity characterized by autonomy and constructivity. Both points can be shared by Popperians; however, it misses the focus on interesting problems and the freedom to apply conjecture and criticism, thereby making and correcting errors without punishment.

The Popperian view of learning is clear: humans learn by solving problems. Problems are conflicts between ideas or mismatches between expectation and experience that cry out for resolution. Genuine problems compel the interest of the individual learner because they are created by the learner (Swann, 2001, p. 210). Interests vary greatly, and therefore it is impossible and not even desirable for all students to be interested in the same problems. For genuine learning to take place, students have to be free to formulate problems, attempt to solve them (i.e., create good explanations), and then error-correct individually and collaboratively. Only through the elimination of errors is genuine growth of knowledge possible. From a Popperian point of view, competence is the practical application of knowledge. The problem of the development of competence can be argued to be a case of solving practical problems, as Swann (1999) suggests. As previously pointed out, theoretical and practical knowledge are subject to the same basic epistemology of problem-solving by conjecture and criticism. Most importantly, all knowledge is merely conjectural and therefore fallible. All forms of learning rely on the same mechanism of critical imagination and criticism, whether through repetition to improve a skill or understanding a new theory. In regard to learning by solving problems, however, problems cannot be imposed on students without causing boredom and resentment. Problems have to be recognized by disappointing existing expectations and are therefore created by the learners themselves.

This methodology of learning has direct consequences for how learning should be conceived in the classroom. The Popperian picture of learning points to the need to open an exploratory landscape rather than adhering to the rigid formalism of the competence education model specified in the curriculum. It means that students need to be given the initiative for exploration. The exploration process may entail dialogical learning, independent research, or any other source of ideas, since, for Popperians,

the starting point does not matter as ideas cannot be judged by their source. It is crucial, however, that real learning always entails a critical element, such as testing a project or the critical discussion of students' conjectures. Criticism and error correction represent the key means of knowledge creation. This includes the view that errors are essential to the growth of knowledge since, by learning from mistakes, our knowledge grows and we are better equipped to deal with problems. Lastly, in dealing with errors, it should be remembered that fundamental errors tend to have higher reach than emergent errors, and error elimination tends to improve our ability to solve problems in general. For instance, fundamental problems of time management represent problems for which their solution tends to improve one's performance in solving other problems. Due to the enormity of the problem landscape, with both fundamental and emergent problems, it is to be expected that students always encounter a multitude of problems in addition to the ones their teachers have conceived for them to solve.

2.4.4. Conclusion: Criticism and Modifications of Competence Orientation with a Focus on Knowledge and Learning

This conclusion briefly reviews how Popperian learning theory can improve competence-oriented pedagogy by first addressing key criticisms and then proposing possible modifications to the curricular pedagogy.

First, the curricular conception of knowledge and competence can be viewed as an instrumentalist account, treating knowledge predominantly as a tool to achieve specific ends. This output-oriented approach is reflected in the three structural features of competence descriptions: the can-do statement linked with cognitive operations and specified educational content. However, according to Deutsch, this instrumental view of knowledge neglects the role of explanation in knowledge creation (2013, p. 110). If a scientific approach to subjects is desirable, explanations must be central. Practical applications of theories are included in this view, but such applications must always rely on theory to provide a meaningful context for practical problems. Otherwise, students are reduced to memorizing, executing, and reciting algorithms to solve problems set by the teacher, whose purpose may remain unclear to them. Popper also criticized instrumentalism as “complacency at the success of applications,” focusing solely on practical outcomes rather than seeking deeper truths (CaR, p. 153). In this sense, the curriculum emphasizes a dispositional account of knowledge at the expense of its explanatory dimensions.

Furthermore, remnants of what Popper termed the *bucket theory of mind* persist in the curriculum. This theory views problems as transmissible, with teachers designing or selecting problems from textbooks and having students practice until they develop competence. From a Popperian perspective, this reliance on external instruction impedes genuine learning (e.g., Burgess, 1977, p. 126). The imagery invoked is of students’ minds as vessels to be filled, whether with knowledge or competence. By practicing on the same problems and learning identical content from knowledgeable sources such as teachers and resources guided by the curriculum, learners are expected to meet predetermined outcomes. This approach reflects the authoritative stance of central educational planning, where learners and teachers are coerced into meeting the educational standards set by the curriculum.

Closely related to the previous point is the problem that the dispositional view of competence generally ignores the personal reality of students and neglects to treat them as autonomous individuals. Students are expected to become competent in areas they cannot choose or, more importantly, opt out in order to pursue something different. The curriculum's input or output orientation is almost entirely determined externally, specifying what students must learn. Despite its insistence on the fundamental importance of individual learners, the curriculum restricts individualized learning to a narrow pathway of predetermined content selected for students.

In light of these criticisms, the following modifications to the epistemology and theory of learning are proposed. First, the curricular epistemology needs a shift toward a problem-based paradigm for learning: problems, conjectures, and criticism should become central components of the learning process. Additionally, promoting a scientific approach to learning requires an emphasis on explanations that are hard to vary, formulated as theories that undergo imaginative criticism by all participants in the learning process.

Moreover, given the universality of epistemology for both theoretical and practical knowledge, it would be beneficial to reduce reliance on rigid competence descriptions in favor of focusing educational goals on a general meta-competence, or problem-solving competence. This broader approach would free education from the restrictions of precise competence descriptions while maintaining structure and rigor. Crucially, fostering students' ability to become competent learners is already an explicit educational goal outlined in the curriculum (Austrian AHS Curriculum, 2023, p. 12). A framework for meta-competence could incorporate at least three dimensions based on Popperian problem-solving:

1. **Ability to formulate problems**: Recognizing and articulating issues that require resolution.
2. **Ability to conjecture solutions**: Proposing tentative explanations or answers.
3. **Ability to engage in criticism**: Evaluating and improving solutions through critical analysis and testing.

By integrating Popperian learning principles into the competence model, educators would gain an explanatory theory of learning that clarifies and operationalizes the

learning process. Progress could still be assessed by both teachers and the curriculum while creating conditions for genuine autonomy. This autonomy—topical, methodological, and social—is a necessary precondition for true learning in the Popperian framework.

Part 3: Principles of Neo-Popperian Didactics in an Austrian Educational Context

> In the first place, what is important is not a particular fact or even a particular ordered collection of facts, but *method*. Itis method rather than information which gives mastery, and it is method which must be the chief business of education. Nor is there any need to insist upon a particular field of human interest in which scientific method can be understood: an educator can use any interest of the student as a vehicle. (Bailey 1977, p. 68f)

The final part of this research project aims to explore and outline the hallmarks of a Popperian didactic approach within the context of the Austrian AHS. It will demonstrate that Popperian teaching methodology succeeds in fulfilling key requirements of competence orientation, which, in its current state, fails to meet its own demands due to overreaching formalism and the resulting neglect of learner autonomy. Crucially, it will be shown that Popperian didactics retains the sensible elements of competence-oriented pedagogy while improving upon it in several aspects. Subsequently, key principles of a Popperian didactic framework will be presented. Finally, the attitude of the open society and the value of traditions will be examined with regard to their implications for fallibilist teaching.

3.1. Neo-Popperian Teaching and its Consequences

This segment explores questions related to the nature of teaching as informed by the Popperian theory of learning. It is followed by a presentation of the key curricular demands for a didactic approach.

3.1.1 The Problem of Teaching

The starting point for this final part of the research project is the discussion of fallibilist epistemology and learning theory (Part II) with the aim of gaining an enhanced understanding of didactics. Central to the development of an actionable Popperian didactics are the identification and subsequent examination of topical focal points where Popperian ideas align well with the curriculum, as well as areas where Popperian learning theory offers a promising alternative to the existing curricular specifications. This constitutes the main problem of this third and final part of the research project. Accordingly, the goal of the following sections is to explore the implications of applied fallibilist epistemology for Austrian AHS didactics.

How Is Teaching to Be Conducted?

Popperian concepts that align with the curriculum include the integration of a Popperian view of learning into teaching practice. A central aspect of this view is the insight that the growth of knowledge is problem-oriented and situated within a specific context, often referred to as a problem situation. Another key idea is the universality of knowledge, which implies that the same logic applies to all types of learning. All learning is an active process of critical constructivity. Furthermore, learning is critical because all knowledge is constructed, fallible, and prone to error. This principle extends to experience, which is inherently theory-laden and influenced by the specific problem situation in which it occurs. Nevertheless, knowledge remains attainable, owing to the tremendous error-correcting potential of criticism. Criticism resolves contradictions and enables continual progression from problems to better problems.

In addition to its epistemological stance, Popperian philosophy upholds key values of both liberalism and the rational optimism of the Enlightenment tradition. Among these values are the emphasis on individualism, freedom of choice, and an appreciation for the knowledge inherent in social institutions. Consequently, didactics derived from Popperian ideas must prioritize the autonomy of the individual learner. This focus necessitates finding ways to facilitate autonomous learning and supporting students in their self-directed creation of knowledge. As Bailey argues:

> The learner does not wait passively to pick information from the outside world, or even have information imposed upon her. She actively explores her environment, generating trials and testing them against that environment. The only instruction that occurs in any learning is initiated by the learner. Obviously, this has tremendous ramifications for education. (Bailey, 2000, p. 74)

Those ramifications hinted at by Bailey will be the subject of this discussion. While the first part—the recognition that learning is an active process—has become widely accepted, the second part, namely that learning occurs through individuals conjecturing solutions to their problems and eliminating errors, remains underappreciated. Teaching, therefore, transforms into a form of educational support for learners, in sharp contrast to the traditional role of knowledge transmission envisioned by didactic theories influenced by the bucket theory of mind.

Popperian educational support emphasizes the open-ended negotiation of problems and constructive criticism as tools to assist learners in creating knowledge. Moreover, Popperian teaching includes fostering an environment conducive to learning by enabling students to explore problems they find captivating through conjecture and

criticism. Such an environment must remove the students' fear of being wrong, allowing for errors and encouraging disobedience in the service of creative exploration. At the same time, it must provide opportunities for conjectural solutions to be tested and rigorously criticized to enable genuine progress.

3.1.2. Curricular Specifications of Competence Oriented Didactics

If a Popperian didactic is to be made actionable in an Austrian educational context, it must address the most important needs of teaching as specified in the curriculum in its current form or improve upon them. What follows is a brief examination of key specifications of the Austrian AHS curriculum regarding teaching. In the curriculum, at least three factors directly influence the didactic approach mandated.

- **The Educational Goals:** Section 1 outlines the intended overarching outcomes of the teaching process.
- **Competence-Oriented Lessons:** Section 2 provides specifications about the competence-oriented approach to teaching.
- **General Didactic Principles:** Section 3 explicitly states the attributes of the intended teaching practice.

These three factors will be briefly surveyed to form the basis for developing a Popperian augmentation of competence-oriented pedagogy. The educational goals set out in the curriculum are detailed in the first section of the AHS curriculum. A specific passage sheds light on the teaching practice envisioned by the curriculum. It states that,

> the general secondary school should promote the individuality of pupils in accordance with ethically sound values so that pupils are prepared for life and their future careers and acquire the skills to acquire education independently. It should enable young people to make independent judgments, impart social understanding and shape an active sporting lifestyle. Finally, the general secondary school should cultivate an openness towards the political and ideological thinking of others and enable young people to participate in the economic and cultural life of Austria, Europe and the world. (Austrian AHS Curriculum, 2023, Section 1, p. 9)

From this elaboration, at least four intended outcomes of teaching can be identified. First is the promotion of individuality among the students. The second point is the preparation for life and occupation through the ability to learn autonomously (autonomy). Third, the cultivation of openness towards the thinking of others implies fallibilism. Lastly, the ability to participate in culture is also mentioned as the most

explicitly social dimension of the teaching outcomes specified in the first section of the curriculum.

Furthermore, specifications of the role of the teacher are also mentioned in Section 1. Here, the curriculum calls for an

> expanded understanding of the role of teachers. They are increasingly called upon to support young people in their search for answers to their questions in a moderating role and to act as learning guides in the development and consolidation of competences. In this context, increased individualization of the learning process also plays an important role. An individualized learning pace as well as continuous learning development should be aimed for. (Austrian AHS Curriculum, 2023, Section 1, p. 9).

The second key influence on the didactic approach prescribed in the AHS curriculum is found in Section 2, "Competence Orientation," which specifies what characterizes competence-oriented teaching. The curriculum states that "competence orientation requires a special understanding of teaching," namely one that accounts for learning as an "active, reflexive, situative, and constructive process" (p. 13). The goal of competence-oriented teaching is that students "acquire knowledge and skills that they can apply and implement in different situations" (p. 13). Furthermore, Section 2 specifies the following hallmarks of competence-oriented teaching (Austrian AHS Curriculum, 2023, p. 13):

- clear communication of the learning goals
- taking the student's lived reality into account
- active engagement with the topic
- action orientation and learning for solving problems
- leading to foundational insights
- leading to systematic knowledge acquisition and association with scientific insights
- implicitly developing extra competences (überfachliche Kompetenzen)
- taking place within a culture of self-reflection which should raise the learners' awareness for the developed competences
- leading to learning experiences that are meaningful and reach beyond the classroom
- encourages students to think critically

The picture painted of teaching in Section 2 of the curriculum can be summarized as teachers creating the framework in which students actively, autonomously, and critically engage with a topic. Furthermore, the role of the teacher is primarily to coach

and facilitate student learning. Teaching should also lead to students perceiving their learning experience as meaningful.

The third influential factor of curricular didactics is Section 3, “General Didactic Principles” (pp. 13–16). It postulates and elaborates on eight principles that teachers are expected to adhere to, which have been detailed in Part I of this research project. In essence, these principles may be summarized as requiring teachers to be open regarding the needs of their students and to new theories of learning.

3.2. Key Issues of Neo-Popperian Didactics

As seen in the previous section, the first three sections of the curriculum represent core factors addressing the vision of teaching developed in the document. A detailed overview of each section can be found in Part I of this research project. Significant factors include:

- ***Section 1:*** *Educational goals aim for individuation, the ability to learn, fallibilism, and the ability to participate in life.*
- ***Section 2:*** *Competence orientation in teaching calls for problem-solving, meaningful experiences, and focusing on the students’ lived reality.*
- ***Section 3:*** *Didactic principles demand individuality, innovativeness, cooperation orientation, preparedness, the creation of an environment conducive to teaching, mutual respect, language sensitivity, and finally, transparency in a competence-oriented assessment scheme.*

It becomes clear that, as it stands, the curriculum provides multiple points of overlap with Neo-Popperian teaching and, at the same time, yields ample opportunities for Popperian learning theory to enhance competence-oriented teaching. This section explores ways in which the main specifications in the curriculum can be addressed and improved by Popperian didactic.

3.2.1. A Problem-based Paradigm

It seems that the goal of achieving learner autonomy, as specified at various points in the curriculum, while retaining the authority and rigidity of centrally planned outcomes at the level of individual competence descriptions specified by the curriculum, is almost

impossible. True learner autonomy and the achievement of predefined learning outcomes seem fundamentally at odds with each other. Thus, the current level of detail with respect to the individual competence descriptions needs to be modified to allow students to make their own educational choices. Such modifications entail at least a deceptively subtle shift in perspective. This shift first changes the conceptualization of the intended educational outcomes and, second, reconsiders how the lesson content is framed, namely in terms of problems and their solutions by trial and error.

In essence, the shift entails what has been suggested in Part II of this work, namely the broadening of the rigid competence descriptions to a general and universally applicable problem-solving competence. This alternative to overbearing and inflexible competence descriptions as mandatory learning outcomes allows for student-initiated learning, as it refrains from overdefining the topics covered and the problems solved. Rather, it focuses on *method instead of content*. In line with Popperian learning theorists, my proposal of problem-solving competence is based on the Popperian problem-solving schema. It covers all three essential stages of problem-solving and their related skills, namely problem formulation, conjecture, and criticism. These, in addition to student autonomy, can be understood as forming the basis of the minimal conditions necessary for learning to take place.

Alongside reclaiming the openness of the educational process by replacing competence descriptions with a general problem-solving competence, the second shift transitions the lesson content from a canon of answers to the exploration of problems. Instead of focusing on predefined answers or learning outcomes that students must achieve—whether by solving teacher-designed problems or by "transmitting" knowledge through lectures—problems and the attempts to solve them should form the core aspect of lesson content. This emphasis on autonomous and exploratory problem-solving also meets the curricular need for learning to be meaningful beyond the classroom and anchored in real-life experiences (Austrian AHS Curriculum, 2023, p. 13).

In a Popperian view, problems represent the starting point of all rational thinking. When turning towards problem orientation as an educator, Swann cautions against failing to “distinguish between the learner’s problems and those of the teacher” (1999). She uses

the example of a teacher asking herself, “How can I help this child to become a reader?” whereas “whatever a child learns will be heavily dependent on the expectations and desires that the child brings to the situation; learning can only take place on the basis of problems that individuals have either created or re-created for themselves” (1999). There is no “direct” transfer of problems between teachers and learners. Considering this shift towards problems, Swann’s warning suggests that teachers' planning needs to be sensitive to students as autonomous and individual creators of problems (1999). Furthermore, teachers need to be wary of confusing teaching problems with the learning problems of their students. Moreover, through a shift towards an open-ended problem-based paradigm, teachers and students alike are liberated from the most restrictive features of central educational planning. Only by rejecting the over-definition of learning outcomes can true student-centeredness, in the curricular sense—namely respect for the individual and encouragement of learning autonomy—be achieved.

This leads to the curricular demand for individuation. Individualizing student learning is a key component of the curricular didactic that is fundamentally compatible with Popperian didactics. The individuation of the learning process, coupled with the promotion of learner autonomy, is front and center in the Popperian picture of learning. In addition, only a fundamental shift from teaching as an authoritative management process of planned competence acquisition towards consent and cooperation orientation (consent-oriented teaching) enables meaningful participation and allows for real learning to take place. Real student-centeredness involves students in their learning while also giving them the opportunity to plan their own educational path.

A concern that traditional-minded educators might have in this regard pertains to the dangers of learner autonomy leading to a laissez-faire approach to education that fails to equip students with the necessary skills to cope with the demands of living in modern (Western) society. However, these concerns are unwarranted. Popperian teaching allows for true learner autonomy while recognizing the importance of educational support. In other words, the problem for teachers becomes how to give students the best educational support while also recognizing them as autonomous individuals. To this point, Fitz-Claridge argues,

> being free does not mean having no educational support. It just means that when we are offering our educational support, help, ideas, suggestions, engagement, and so on, we are sensitive to whether or not our engagement is welcome in that moment, and when it is not, we back off, just as you would in any good relationship. Children are sovereign individuals: their lives are their own. They are entitled to the same freedom, rights, respect and control over their lives and learning as we are. (Fitz-Claridge, 2023)

Therefore, it is an unwarranted fear that Popperian teaching leads to teachers abandoning students to "fend for themselves" educationally. The quantity and level of educational support are always dependent on the individual learner. Some students feel the need to receive suggestions from the teacher or colleagues, while others prefer to be left alone. Some may like to solve a problem completely independently before discussing it, while others appreciate critical feedback at different stages of the problem-solving process. Similarly, some students prefer to solve problems in groups, while others may choose to work alone at times. The clear strength of adopting a Popperian approach to teaching lies in its epistemology and the method derived from it. This approach is universally applicable to any learner and any problem while still accounting for the differences that make learning an individualized process.

3.2.2. Fallibilist Teaching: Methodology and Practice

The centerpiece of Popperian teaching is its methodology, which derives from its epistemology. According to Burgess, the method of learning is more important than any particular theory (1977, p. 134). This presents teachers with the challenge of helping students master the universal method of learning and use it autonomously. In searching for an actionable teaching methodology, it is advisable to return to the basic mechanism of learning and reflect on how students can be assisted in the learning process. The basic schema of the logical structure of learning has been outlined by Popper as follows (OK, p. 119):

P1 → TT → EE → P2

As discussed previously in this work, the logical schema of learning as problem solving consists of the progression from problems (P1) to new problems or modified versions

of the same problem (P2) by means of conjecturing tentative solutions[1] (TT) and subjecting those to criticism and therefore engaging in a process of error elimination (EE). The first task of a Popperian didactic, then, is to enable, or at least not stifle, these four stages of learning and their progression.

Problems as Starting Point

In accordance with the Popperian problem-solving schema, all learning starts with the identification of a mismatch between expectation and experience or a conflict between ideas (Swann, 2012, p. 89). Every area of knowledge, whether it pertains to traditional academically defined subjects or nonscientific knowledge, is organized around problems and attempts to solve them. Unfortunately, this is not the typical way of conceiving what is to be learned. Traditionally, lesson content has often been presented as a collection of facts to be memorized or skills to be acquired through repetitive drills, with the teacher controlling student behavior as well as the social configuration at every stage of the lesson plan. However, if teachers are to assist students in learning, as required by the curriculum (Austrian AHS Curriculum, 2023, p. 9), then a shift towards viewing knowledge and skills as addressing problems is an invaluable first step. Furthermore, taking a problem-based view of lesson content aligns with the problem orientation inherent in the didactic approach of competence orientation.

In their preparation, teachers may benefit from analyzing and formulating their subject-specific knowledge in terms of problems. Swann's (1999) distinction between theoretical problems that answer "what" questions and practical problems that address "how can" questions is an attractive tool for understanding one's subject from a problem-based perspective. Conjectures for theoretical problems involve creating good explanations—ones that are hard to vary and tested against logic. For practical problems, such as building a paper plane, conjectures involve testing the end product against the environment.

[1] Following Swann, the term tentative solution is used here since it encompasses practical problems better. Popper used TT as signifying "tentative theories", which highlights his focus on theoretical problems. However, since all problem solving involves some form of theory formation the preferred use of "tentative solution" instead of "tentative theory" is only nominal.

Still, teachers preparing material in problem format is not sufficient for a Popperian teaching methodology. If teachers formulated problems and then required learners to solve them exactly as intended, this would constitute instruction from without—an obstacle to learning. Teaching, from a Popperian perspective, must consider the learner as a creative individual. For example, when an English teacher formulates the problem of ordering food in a restaurant, students themselves must (re-)create the problem. For learners, it is crucial to understand that problems are created by them. The problematization of a mismatch is always an act of creativity and involves the learner's prior theories, which characterize their problem situation.

When asking what should be learned, one must remember the teacher's role as a moderator, facilitator, and overall supporter. The answer to what should be the subject of creative engagement may be: "What fascinates students is where problems are created." Consequently, teaching must allow flexibility in varying and modifying the problem at hand and give learners opportunities for autonomous exploration, both methodologically and socially. Returning to the illustrative problem of learning to order at a restaurant, English teachers could allow for adaptations. For instance, some students might adapt the problem to "How do I request vegan options at a restaurant?"—a narrower form of the original problem formulated by the teacher. Others might broaden it to "How can I get a table at the restaurant before I order food?" Both adaptations are valid ways to vary the problem, and students should always be granted a say in making the problem interesting.

However, the role of teachers is not to simply let students go their own way with a problem and remain uninvolved. Rather, the teacher’s role is to actively provide educational support. A deeply important aspect of supporting learners involves educational provocation. It is the task of teachers to provoke students' interest through questions and statements that help them identify interesting problems. Frequently, teachers can help students recognize conflicts between ideas or highlight mismatches and inconsistencies by questioning students' theories, comparable to the Socratic method. Such instances encourage students to rethink previously unproblematic ideas when a gap between expectation and experience emerges, prompting them to investigate further.

From a Popperian perspective, it is also insufficient to merely provide students with problems; one must accept that students may not be willing to engage with the problems as they are initially presented. David Deutsch argues that

> people are not just creative abstractly. They are solving problems. And if the problems don't lead to satisfactory new problems, then they turn to something else. The thing only stays interesting when solving a problem leads to a better problem (Ravikant, 2023a).

Since all knowledge is fallible, even teacher-posed problems can be improved to better engage learners. In any case, the search for interesting problems must involve the learner and take place collaboratively.

Conjectures as Attempted Solutions

Creativity, aside from the formulation of a problem, is one of the most important aspects of problem-solving. Creativity, however, requires the freedom to explore solutions to problems. Swann criticizes that oftentimes in lessons,

> not only are opportunities to engage in trial and error-elimination limited, many schools are also unsafe places in which to discover errors and inadequacies because revealing them tends to occasion a penalty of some kind. Teachers are put under pressure to produce individuals who are able to perform a limited range of tasks according to narrowly conceived standards. In such circumstances, the tendency is to penalise the student for failing to understand, failing to give the prescribed answer, failing to agree, failing to conform. (2007)

Once a problem has captured the learner's interest, they must be free to create tentative solutions without fearing the penalization of errors, either formally or informally. Formal penalization means that errors made in the learning process affect the student's grade, while informal penalization includes emotional reactions like expressions of distaste, disappointment, or frustration. Instead of penalizing errors, teachers should support and encourage students in their attempts to create solutions to their problems. Whether learners face a theoretical or practical problem, all problems require them to make guesses to find possible solutions. Both the conceptualization phase of a problem and the phase of attempting to find a solution are highly fallible processes in which errors are the norm rather than the exception. Depending on the problem, a solution will, at some point, involve an explanatory theory created by the student. Allowing students to be creative entails granting them both methodological and social autonomy. Learners need to be free to choose their starting point and approach to solving the problem at hand. Furthermore, they should be allowed to use the theories they find relevant without excessive teacher interference. Mistakes are expected to happen and represent a key mode of progress, as learning from errors is one of the most important ways in which learning takes place from a Popperian point

of view. In addition to autonomy of method, students also need the option to solve the problem individually or with other learners. This is an important aspect of recognizing learners as individuals with unique social preferences.

In proposing solutions to problems, risk-taking, in the sense of putting forth bold conjectures, should be rewarded. As Burgess argues, an important goal of teaching is to assist learners in developing the confidence to formulate solutions and think outside the box (Burgess, 1977, p. 160). According to Deutsch, one must be able to deviate from the expected path to be creative, so disobedience with respect to the acceptance of pre-made solutions is to be expected and tolerated in a setting conducive to learning (personal communication, June 14, 2024). Humans, in a Popperian view, always try to solve some problem, and teaching, in the broadest sense, then means helping students do what they want to do.

Criticism as Error Elimination

All learning is underpinned by an exploratory process of trial-and-error elimination. Every theory from any source of knowledge must be constructed creatively and through conjecture and criticism by the learner. As previously stated, in order to be creative, students need the autonomy to address problems methodologically and socially in a self-determined manner. The next key part of a Popperian teaching methodology involves criticism. As discussed in Part II of this research project, criticism is one of the most important concepts in Popperian philosophy. Only a critical attitude with respect to all knowledge claims enables true progress. Criticism also goes hand in hand with the rejection of authority and the motivation to think differently while being open to the thoughts of others.

Thus, a principal function of the teacher is to facilitate criticism in different social modes, besides helping students find and formulate problems as well as helping students conjecture possible solutions. A crucial part of criticism is pointing out errors in the learners' attempts to solve problems. Such errors can be found in the problem formulation itself or in the proposed solution. For the former, a teacher might ask, "What does the proposed solution do with respect to the problem at hand? Does it reveal inadequacies in the initial problem formulation?" For the latter, the teacher may help students find contradictions and inconsistencies in their theories and thereby provoke

deeper thinking. For Deutsch, “knowledge creation is not only subject to error: errors are common, significant, and always will be, and correcting them will always reveal further and better problems” (2012, p. 65). Therefore, Popperian teaching will be highly tolerant of errors, as required by the curriculum (p. 14). In this regard, a Popperian didactic approach radicalizes the error tolerance demanded in the curriculum by pointing out that progress essentially means learning from one’s mistakes (Popper, CaR, p. 173).

In addition to criticism as a function of educational support by the teacher, there are further social dimensions in which criticism plays a role in the learning process. First, self-criticism and reflection are key aspects of problem-solving competence and, in the case of self-reflection, explicitly demanded by the curriculum (2023, p. 13). This presupposes at least an intuitive understanding of the fallibility of knowledge and its creation, as well as the ability to differentiate between person and problem.

In practice, students may get discouraged or even defensive when thinking about the errors they have made in trying to solve a problem. Such a defensive attitude typically results from a lack of understanding that learning is necessarily a trial-and-error process and that errors do not reflect the quality of the learner’s character. The opposite of this defeatist attitude is the open attitude. It results from an understanding that learning requires error and its correction and that knowledge and its growth are always fallible. However, in order to create an environment in which an open attitude is possible, students, as well as teachers, have to cooperate. Apart from self-reflection and self-criticism, a classroom environment can draw on the critical imagination of all students and therefore allow for critical engagement with the problem solutions of other students. Crucial aspects of this are the identification and critical discussion of errors in attempted solutions.

Overall, the critical engagement with problem solutions represents the crucial phase of error elimination in the Popperian learning schema. Here, different social modes play a significant role in the learning process. First, the teacher is an important critical resource, and criticism represents a fundamental part of true educational support. However, not less important is the student’s competence in criticizing their own theories as well as helping their peers find errors in their problem-solving.

Excursion: How to Deal with Generative AI?

The recent advancements in AI have posed unanswered questions for the field of education. Prominent worries include the lack of trust in students' texts that have not been produced during the lesson. This is due to the belief that students who use operative AIs fail to learn by delegating the “real work” to the AI. Yet, the function of operative AIs can be seamlessly integrated into the Popperian problem-solving schema. Every use of AI starts with a problem. The problem is therefore not defined by AI but by the user. In the case of using OpenAI’s ChatGPT, defining the problem and initial guesses on how to approach it must be formulated in the prompt. Where AI comes into play is with respect to the conjectured solution. Psychologically, it is a mystery where one’s own conjectures originate, and, more importantly, it is not epistemically important where the proposed solution comes from. What truly matters is the critical engagement—the creative engagement with the solutions—that is done by the learner. Thus, the schema would look as follows:

P1 (User) → CS (AI) → EE (User/AI) → P2 (User).

In this schema, P1 is the problem formulated by the user as a prompt. It seems to be often overlooked that prompt generation itself is a highly creative act of conjecture and criticism. Following the problem formulation is CS, the solution proposed by the AI. After the CS by the AI, the second important act of creativity, EE, is the error elimination process realized by the imaginative criticism of the user. P2 is the new problem at the end of the process or a refined reformulation of the original problem.

In assessment, this means that the student’s creative input is the focus. Therefore, criteria for assessing the use of ChatGPT might include interviews in which students present their use of generative AI. This may be supplemented by chat logs detailing a prompt history with the specific AI tools for transparency reasons. The most interesting aspects of assessing problem-solving with the help of AI tools from a Popperian perspective are the quality of the input by the user as well as the critical engagement with the output. No AI can solve a problem that is outside the student’s problem situation; a problem needs to be the student’s own in order to use generative AI to solve it. Prompts still represent active conjectures by the user and are to be viewed as

acts of creativity, as they are attempts to formalize a problem and to prompt further conjectures. According to the previously proposed meta-competence schema, generating a usable prompt falls under the category of problem formulation. This step is crucial in the problem-solving process, even though the prompt itself presents only a minuscule part of the total text. The second crucial act of creativity on the user's side is the critical evaluation of the output and further procedures. Since all conjectures are fallible, so are those of a generative AI, and it remains the task of the user to make critical decisions based on the output, including error correction and reformulations of prompts. Overall, it seems that generative AI is not the end of creativity for students, as many educators seem to think. Rather, it provides an invaluable tool for students' problem-solving.

3.2.3. Educational Support: Consent Orientation and Co-constructivity

In the previous discussion of Popperian teaching methodology, the three aspects of problem-solving and the teacher's role in them were sketched. This section highlights key features of a Popperian conception of educational support, which are based on epistemological fallibilism and student autonomy. The epistemological stance of critical rationalism is consistently fallibilist, and therefore any Popperian didactic approach must reject authorities with respect to knowledge claims. This epistemic non-authoritarianism in education means that there is nothing that is not, at least in principle, open to criticism. Everything can be called into question, as there are no authorities in the sense that the source of knowledge guarantees truth. At the same time, Popper expressed the sentiment that since the origins of the sources do not matter, "every suggestion is welcome," provided that it also submits itself to criticism (CaR, p. 36).

Teaching as Negotiation

In applying fallibilism to knowledge creation, errors are valuable products of the learning process as they provide learners with the opportunity to detect them and improve upon their problem solutions (Swann, 1999). In its application to the teacher-student relationship, it must be cautioned that one of the main dangers of teachers using the voice of authority lies in entrenching misconceptions in the learners (Deutsch, personal communication, June 14, 2024). Often, learners are bullied into believing

something that has not been understood. To mitigate the dangers of an authoritarian relationship, negotiation, instead of coercion, represents the main mode of educational support. This is achieved at the problem formation level by teachers making suggestions for a problem but accepting alternative problem suggestions. In other words, problems are to be negotiated, not dictated.

Such an approach to teaching is essentially consent-based, relying on an assumption of cooperation instead of coercion. Further aspects of negotiation include critical questioning at the problem-solving level. In solving a problem, learners automatically test their ideas against logic and, in the case of project work, for instance, feedback from the environment. Teachers can help students in this process by offering criticism and suggestions for improvement. However, it is crucial to keep in mind that learning can only happen if the learner is actively trying to solve a problem. The task of the teacher is a special kind of the established teaching method of “scaffolding,” by which teachers dialogically help students solve a problem without destroying the learning effect by lecturing the necessary steps to students. Rather, students are to be assisted in solving the problem themselves.

This leads to the question of what to do if students do not fill the “mental gap” that the teacher has prepared for them. The answer is simply an acknowledgment of the difference in people’s approaches to a problem. Moreover, disobedience can only happen in relation to an authority. However, an important aspect of learning is creative criticism, which requires students to not blindly accept and follow what is presented but independently and constructively explore and challenge knowledge claims.

Creating Learning Spaces

Another relevant issue with educational support is the environment in which it takes place. Since classes are legally required (Schulunterrichtsgesetz, 2024, §9), there is a stable community of learners with widely differing needs, expectations, interests, knowledge, and skills. In order to truly serve the learners, teachers and learners both need to be engaged in an ongoing negotiation process, thereby collaboratively creating learning spaces. Popperian learning theory can offer relevant suggestions for the creation of such environments. Hallmarks of learning spaces include ensured openness, freedom to explore, and voluntary interaction without fear that being wrong

leads to punishment. In short, topical, methodological, and social autonomy in learning are only possible if the structures in which the learning is supposed to take place are flexible. It may well turn out to be impossible to design one type of learning environment that truly meets the needs of all students.

However, in envisioning a space that is conducive to learning, one may keep one criterion in mind that oftentimes is not given appropriate attention, namely that it must also be possible to have fun. Here, “fun” is meant in the sense of experiencing joy in solving one’s problems. Deutsch offers a theory of happiness that is deeply epistemological. He speculates that:

> Happiness is a state of continually solving one’s problems […]. Unhappiness is caused by being chronically baulked in one’s attempts to do that. And solving problems itself depends on knowing how; so, external factors aside, unhappiness is caused by not knowing how. (Deutsch, 2012, p. 318f)

In accordance with the theory that happiness is a state of successful problem-solving through knowledge creation, Deutsch’s (2019) concept of the “fun criterion” may be applied as a quality control tool for the learning environment by posing the question: Is it possible to have fun? In Deutsch’s (2019) conception, the human mind is inhabited by at least three different kinds of ideas: explicit, inexplicit, and unconscious ones. All of these different kinds of ideas continually affect each other and can be in conflict. Explicit ideas are those that can be articulated and made conscious but are regulated by inexplicit knowledge. For instance, while we follow grammatical rules when speaking, we often cannot explicitly describe those rules. Explicit ideas constitute our theories and can be tested by logic and experiment (Deutsch, 2019). Inexplicit ideas are then conscious but not directly expressible in language, playing a crucial role in actions and thoughts that require intuition and non-verbalized understanding. Lastly, unconscious ideas influence behavior and feelings without the individual's awareness and cannot be directly accessed or articulated. The important point is that, for Deutsch, all of these types of ideas obey the same epistemology: “none of them can ever be justified, all of them can be mistaken, […] all of them are corrected by a process of problem-solving with conjecture and criticism” (2019).

According to Deutsch's criterion, fun is had when all kinds of ideas can solve problems without getting in each other's way. Importantly, lack of fun is a type of criticism of the present situation. It indicates that problem-solving at the level of the different types of

ideas is incompatible with each other (Ripples, 2021). The mind itself constitutes an environment in which having fun is the result of problem-solving through conjecture and criticism. In the mind, different kinds of ideas interact and evolve (Deutsch, 2019). Any external learning environment, then, has to allow for problem-solving by conjecture and criticism in order to be one in which one can have fun. So, Deutsch's criterion applied to the classroom can be formulated in the question: What stands in the way of having fun, and how can it be improved? Learning spaces are places where ideas of all types, such as theories, motivations, and emotions, come into contact with each other and allow for problem-solving by conjecture and criticism. This stands in stark contrast to traditional classroom settings with, for example, rigid seating arrangements. In rethinking the arrangements of a learning space, one may be guided by thinking about what stands in the way of having fun and then embark on an open-ended negotiation with the learners in order to help harmonize the different modes of criticism: explicit, inexplicit, and unconscious.

3.3. Two Issues of Neo-Popperian Didactics

In addition to an outline of a methodology of teaching as well as highlighting key principles of educational support, there are two related issues that shape the way a didactic approach following Popperian principles can be conceived, namely the negotiation between tradition and the open attitude. This section starts with Popper's distinction between the cultural attitudes of open and static societies and applies these attitudes to teaching. Then, a Neo-Popperian treatment of memes is attempted in order to make sense of the second issue, namely, a Popperian way of understanding tradition and its value for education.

3.3.1. The Open Attitude in Education

In *The Open Society and its Enemies*, Popper argues that open societies and closed societies can be distinguished, among other things, in their tolerance of rational criticism (OS, p. 165f.). The attitude of the closed society aims to remain stable by either trying to arrest change or, if this is not possible, by planning and controlling change. Both approaches, according to Popper, lead to irrationalism (OS, pp. 419–420). Centrally planned education represents one of the instances in which an open process gets unduly undercut by the authoritarian attitude of a closed society (Corson, 1985). Indicative of central educational planning are the extensive definition of educational outcomes and a general move towards standardization both in teaching and testing.

Opening Current Educational Practice

In an interview, Deutsch speaks about problematizing the coercive nature of current teaching practices stating:

> Whenever I criticize a particular feature of existing educational practice, like, say, exams, then the natural thing is to, is to say, well, how will the knowledge get into them? OK, some of them will want to learn that, but some of them won't, and what about those? And this, some of them won't, and some of them will, that's all the wrong theory. It's all the wrong picture. Like if somebody doesn't want to learn something on the curriculum, it's because they are learning something else. They might be making a mistake or you might be. And the way to solve that kind of issue is to discuss it and to bring criticism to bear and to respect not only the principles of epistemology broadly, but specifically the principles of liberalism, which already tell us,… we're lucky for hundreds of years now, we've had liberalism, which has already solved the apparently intractable problem of how you get people who have different views about things to live together without violence. Now that's not enough for an education theory, but it's a thing an educational theory ought to respect and conform to. (Khemani, 2023)

Deutsch's key point here is that the tradition of educational theories has perpetuated mistaken views of the problems of education. Current educational theories conceive their success in how well teachers manage students to obey their plans for them. Yet, teaching in an open society loses its authoritarian character and moves to "encourage a conjectural spirit in their pupils" (Corson, 1985). Instead of passing down knowledge or drilling students to reach specific learning outcomes, teachers in an open society should work actively to help create a culture of criticism in the classroom, encouraging students to go beyond their own convictions without coercing them.

Openness in Teachers

No less important than the educational theories are the teachers themselves. As stated in the previous segment on methodology, the role of teachers is to assist students in all stages of problem-solving. But more general than that are considerations of what characterizes good teachers beyond their didactics. In other words, what are the values that allow teachers to contribute to an open society?

The quintessential Popperian answer to this question would be that teachers need to be open to change. This openness depends on the individual teacher's ability to accept at least three points. First, a teacher needs to acknowledge their fallibility. Since humans err, everything that teachers think they know might be superseded by better knowledge—knowledge that contains fewer errors and helps solve their problems better. To do this, teachers need intellectual modesty. Secondly, teachers need to understand the Neo-Popperian point that humans are universal explainers and that the same epistemology applies to all kinds of human knowledge and people (cf. Deutsch, 2012, p. 157). To think that children obey a different kind of epistemology is mistaken and harmful, according to Deutsch (personal communication, June 14, 2024). Thirdly, as a consequence of acknowledging the fallibility of human knowledge as well as the universality of human epistemology, an open teacher must abandon the authoritative stance. Zecha summarizes this point, arguing "that it is not his task to be a leader or ruler in the classroom. Rather, the secret of intellectual distinction lies in the spirit of criticism that leads to intellectual independence" (2019, p. 648).

Open Society in Schools

Popper's sketch of an open society can be described essentially as a form of social configuration emphasizing individual liberty, an appreciation of tradition with an anti-revolutionary stance in favor of incremental improvements, and great confidence in the value of social institutions. The open society is also characterized by anti-utopianism as a consequence of fallibilism applied to social life and aimed at progress through criticism by its members.

Since the open society is the only cultural environment in which rapid progress is possible, this cultural attitude applied to education would, among structural changes, fundamentally transform the way in which didactics are practiced at schools, while at the same time seeking to preserve the valuable knowledge that has already been created in such institutions. In a progressively open educational institution, systems of consent and criticism have to be set in place where central planning once was. New ideas may include Swann's call to use student-initiated curricula (1999) or Bailey's (2017) suggestion of implementing a criticalist curriculum. Regardless of any specific idea, an open attitude would result in a variety of different approaches and encourage innovation. The key requirement for progress in education is the same that Deutsch calls the "moral imperative not to destroy the means of correcting mistakes" (Deutsch, 2011, p. 235). As long as it remains possible to correct errors, it is possible to make progress. Furthermore, there are constants that can be used to clearly differentiate open education from closed education. An education based on the values of an open society will encourage diversity, autonomy, criticism, and creativity in its learners in order to help them become maximally different people.

3.3.2. Tradition and Memes in Education

Schools are instances of educational institutions creating environments in which different cultures constantly come into contact. Each culture has developed traditions that, along with social institutions, help to cope with the various demands of social life. Traditions, for Popper, refer to shared values, attitudes, and aims, whereas institutions represent norms in order to fulfill a social function or purpose (CaR, p. 178). Traditions are more personal than institutions in Popper's view and "take […] an intermediate place, in social theory, between persons and institutions" (CaR, p. 179). Popper compares the two, claiming that

> institutions and traditions have much in common; among other things that they must be analysed by the social sciences in terms of individual persons, their actions, attitudes, beliefs, expectations, and interrelations. (CaR, p. 178)

Besides those possibilities of analysis, Popper places great emphasis on the necessity and purpose of traditions, namely, to solve problems of social life. He argues that

> we could not live in the social world, did it not contain a considerable amount of order, a great number of regularities to which we can adjust ourselves. The mere existence of these regularities is perhaps more important than their peculiar merits or demerits. They are needed as regularities, and therefore handed on as traditions, whether or not they are in other respects rational or necessary or good or beautiful or what you will. There is a need for tradition in social life. (CaR, p. 175)

Thus, in the Popperian picture, traditions help us control the felt chaos that is presented by the world by explaining it and making it predictable. Popper likens the function of traditions to the function of scientific theories in this respect: they are used to order social life and establish regularities (CaR, p. 175). Moreover, Popper argues that, like scientific theories, social traditions, in addition to their ordering function, serve as a basis for change through rational criticism.

> The analogy between the role of myths or theories in science and the role of traditions in society goes further. We must remember that the great significance of myths in scientific method was that they could become the objects of criticism, and that they could be changed. Similarly traditions have the important double function of not only creating a certain order or something like a social structure, but also giving us something upon which we can operate; something that we can criticize and change. (CaR, p. 176)

In addition to its ordering function, Popper views tradition as one of the primary sources of knowledge. He claims that “every day we do hundreds of things under the influence of traditions of which we are unaware. But if we do not know that we are acting under the influence of a tradition, then we cannot help accepting the tradition uncritically” (CaR, p. 164). Of course, in line with fallibilism, traditions are not perfect and are in constant need of improvement. However, contrary to anti-traditionalist sentiments, Popper cautions that traditions have to be understood before they can be criticized rationally (ibid.). An example of a tradition in the Popperian sense is the critical tradition, which also serves as the precondition for the scientific tradition. Popper claims that

> the Greek philosophers invented a new tradition—the tradition of adopting a critical attitude towards the myths, the tradition of discussing them; the tradition of not only telling a myth, but also of being challenged by the man to whom it is told. Telling their myth they were ready in their turn to listen to what their listener thought about it—admitting thereby the possibility that he might perhaps have a better explanation than they. This was a thing that had not happened before. A new way of asking questions arose. (CaR, p. 170)

In schools, almost everything is permeated by traditions, from the design of the physical spaces, such as the architecture and the classrooms, to the internal organization of the school, all the way to the didactic approaches and the teaching materials that teachers employ. In an important way, all educational institutions can be viewed as evolutionary arenas in which different traditions are replicated and sometimes modified.

Cultural Replicators

This leads to the concept of memes, a term coined by Richard Dawkins in *The Selfish Gene*, which refers to cultural replicators that share some similarities but also significant dissimilarities with genes. In *The Selfish Gene*, Dawkins states that "the analogy between cultural and genetic evolution has frequently been pointed out, sometimes in the context of quite unnecessary mystical overtones. The analogy between scientific progress and genetic evolution by natural selection has been illuminated especially by Sir Karl Popper" (2006 [1976], p. 247). He further describes the similarities, stating, "just as genes propagate themselves in the gene pool by leaping from body to body via sperms or eggs, so memes propagate themselves in the meme pool by leaping from brain to brain via a process which, in the broad sense, can be called imitation" (ibid).

Dawkins's conception of the meme as the product of cultural evolution has been taken up by David Deutsch and modified in his 1994 essay *The Evolution of Culture*. He focuses on the following aspects of memes: First, he points out the differences between memes and genes, namely that memes, unlike genes, can be consciously varied and criticized. This is essentially what Popper means when he claims that we can let our ideas die instead of dying ourselves (OK, p. 248). A second important difference between genes and memes is the selection criteria for memes. According to Deutsch, memes have to be selected twice. First, a meme has to be copied from one holder to the next, which is already a process with much-reduced fidelity compared to the copying of a gene. Since direct transmission of ideas is not possible, the meme has to be recreated by the new holder. The second selection happens as memes are understood, criticized, and therefore modified within the mind. As Deutsch puts it, "the overwhelming majority of memes that fail to be propagated, fail not because their holder dies or is physically prevented from propagating them, but because the holder

chooses not to act upon them and acts upon variants instead" (1994). He also stresses that, unlike genes, memes, because they are not subject to sexual replication, "are intrinsically much faster and more flexible" (1994). Crucially, people act on memes because they bestow some kind of benefit on their holders. Examples of memes include all types of cultural replicators, such as successful jokes, religious taboos, and deep philosophical or scientific theories.

The cultural significance of memes lies in their immense influence. They have the power to shape individual behaviors on the one hand, while also organizing entire societies on the other. Deutsch (1994), in the Popperian tradition, distinguishes between "static" and "dynamic" societies, which approximate Popper's distinction between "open" and "closed" societies. Static societies, according to Deutsch, propagate and enforce anti-rational memes. These are memes that force the holder to be copied faithfully by enacting taboos that suppress critical thinking. Deutsch argues that "static societies always have traditions of bringing up children in ways that disable their creativity and critical faculties. That ensures that most of the new ideas that would have been capable of changing the society are never thought of in the first place" (2012, p. 382). In contrast to this, dynamic societies allow their holders to search for useful truths in order to solve their problems. This leads to the emergence of rational memes, which are, in essence, ideas that replicate through the holder's critical faculties (Deutsch, 2012, p. 196).

Tradition and the Transmission of Memes

Burgess and Deutsch both view educational practices as limited by focusing almost exclusively on the *transmission* of ideas and practices. Deutsch argues that

> even in the best societies, education systems are explicitly designed to transmit knowledge faithfully. It's obedience in a very important narrow sphere—namely, academic knowledge and human social behavior. In those respects, the overt objective of education systems is to make people behave alike. You can call that obedience. But whether you call it obedience or not, it's not creativity. (Ravikant 2023b)

In other words, schools are environments in which memes are consciously spread by imparting traditional knowledge to students. Much of long-standing traditional knowledge consists of successful memes, both rational and anti-rational (Deutsch, 1994). The fatal flaw of anti-rational memes is that they tend to neglect or actively seek to suppress innovation and progress through criticism and attempted modification of the traditions. A prime example of such an anti-rational meme is the view that the truth

of a theory is dependent on its origin. By acting on this anti-rational meme, the holder closes the door to progress by neglecting content in favor of origin. Yet, there has been a rational counter-meme to this anti-rational meme, framing the mistaken view as an instance of the genetic fallacy. In regard to dealing with anti-rational memes, Deutsch suggests,

> when we think we have detected an anti-rational meme, whether in ourselves or in others, the immediate task is to understand how it works. Only then can we create the knowledge both to defy it and to replace any beneficial functions it may have. Our future depends on whether enough of us have the will and creativity to liberate ourselves, in our own lives, from the tyranny of anti-rational memes, while rescuing the immense knowledge that they contain. (1994)

Deutsch makes a crucial point that aligns with Popper's assertion: a tradition or piece of knowledge must be understood in relation to the problem it seeks to address before it can be effectively transcended. Tradition continues to hold a vital role in a fallibilist theory of education because, as Popper points out, most knowledge is traditional, including the tradition of criticism. He argues,

> quantitatively and qualitatively by far the most important source of our knowledge—apart from inborn knowledge—is tradition. Most things we know we have learnt by example, by being told, by reading books, by learning how to criticize, how to take and to accept criticism, how to respect truth. (CaR, p. 36)

Every type of knowledge is fallible, and so are traditions. In the Popperian picture, one needs to first understand and then subject traditional ideas to criticism. Popper even claims that “the advance of knowledge consists, mainly, in the modification of earlier knowledge” (CaR, p. 37). Therefore, one would be mistaken to either reject traditional knowledge altogether or, on the other hand, fully embrace tradition by refusing to deviate from the textbook, for instance.

Traditional Knowledge in Teaching: A Map of the Problem Landscape

Progress has been made, even though much is yet to be understood. The Deutschian phrase is that we are always “at the beginning of infinity,” that is, at the start of an open-ended stream of knowledge creation (2011). Because we have inherited much traditional knowledge, we do not have to literally “reinvent the wheel” every time we are confronted with a problem. We can draw on the vast amount of knowledge that has already been created. However, in the transition from a static to an open society, one should be sensitive to the kinds of memes that cause one to act and especially try to identify and scrutinize anti-rational memes in oneself and others. Rather than merely reciting extant theories, they should be understood and treated as past attempts to

solve problems and not as possessing authority because they are traditional or “canonical” (c.f. Niemann 2008, p. 355). A rational approach to tradition in education would entail taking traditional theories seriously as attempted solutions to problems but also aiming to help students develop their ability to critically engage with them.

Tradition can therefore be broadly conceptualized as a map guiding us through a problem landscape. It may be the wrong map for the problem at hand and must be modified or replaced altogether, or it may be sufficient to resolve the problem to the satisfaction of the learner. Nonetheless, drawing on traditional knowledge in the classroom is a valuable tool to bring order into the chaos that is a new problem. However, just as common wisdom claims, it is important not to confuse the map with the territory. In the context of drawing on traditional theories in the lesson, it is important to remember that such theories should not be followed blindly or uncritically but rather seen as helpful tools that are subject to our critical evaluation for the purposes of the learner’s problem situation. Swann has argued that it is impossible to receive ready-made ideas either from books or teachers or the environment (2012, p. 90). It therefore seems useful to contextualize traditional answers in light of the problems they tried to solve. She also points out that the learning process starts with the learner’s prior expectations and that this has to be considered in trying to teach traditional knowledge (1999). She argues that “by engaging with the world of public knowledge, we are able to invent and reinvent ideas more quickly; our engagement is necessarily active and involves us in a creative process of conjecture, modification, and refutation” (1999). A Neo-Popperian approach to tradition therefore rejects orthodoxy as much as anti-traditionalism. It embraces traditional knowledge for what it is—potentially useful in helping to solve problems, yet always fallible.

Conclusion

Austrian education legislation largely specifies the structure, function, and educational outcomes expected of the education system. Among the legislative documents that set these expectations for schooling are national curricula, which prescribe not only expected educational outcomes but also the didactic approach taken by educators. Naturally, curricula are informed by theories about knowledge, learning, and teaching that significantly shape the approach to education in such documents. This research project represents an attempt to explicate these theories in the hope of aiding their improvement.

It does so not only by attempting to understand the epistemological assumptions underlying the Austrian AHS curriculum but also by criticizing and modifying it using insights from Neo-Popperian epistemology. Three central concepts were considered: knowledge, learning, and teaching. In the first part of this project, curricular specifications of all three concepts were examined and explicated. The second part presented core precepts of Popperian philosophy and discussed a selection of Neo-Popperian concepts that could serve as useful tools in criticizing and ultimately modifying the curricular notions of knowledge and learning. In the third and final part, principles of a Neo-Popperian didactic approach were discussed, with a particular focus on modifying teaching in light of Popperian learning theory. A brief summary of the core insights of this research project is presented:

First, in the Austrian education system, curricula are largely output-oriented and define what students must be able to know and do. The overarching educational goals of the AHS are to help students develop into autonomous individuals, to provide them with a deepened general education, and to prepare them for tertiary education. The curriculum of the Austrian AHS is informed by the epistemology of competence orientation. The educational paradigm of competence orientation views the desired products of education as skills, or the ability to successfully achieve certain goals. It is also problem-oriented and aims for tasks to be meaningful to students.

The main points of overlap between the competence-oriented epistemology of the curriculum can be found in the emphasis on learner autonomy and the general problem orientation. However, several important points of criticism regarding the curriculum and

its epistemological outlook can be made from a Popperian point of view. Regarding the curriculum as a foundational document prescribing learning content as well as the didactic approach, it lacks transparency with regard to the theories it draws on and the extent to which it incorporates them. For a document that holds this much power in the education system, the curriculum is strikingly far removed from good academic practice by failing to clearly detail the theoretical framework in which it is conceived. It thereby leaves it to the individual researcher to infer large parts of the curricular epistemology from the claims it makes—a task which has been attempted in Part I of this project.

Even more important than the criticism of the document and its conception are the points of criticism of the epistemological assumptions in the curriculum, offered by Neo-Popperian theory. First, the competence-oriented paradigm as specified by the curriculum displays an instrumentalist attitude towards knowledge. It treats knowledge and skills almost exclusively as means to achieve certain ends. This becomes obvious in the rigid competence descriptions, which are formulated as can-do statements and then specify certain educational outcomes. One of the dangers of the instrumentalist view of knowledge is its negligence of the explanatory power of knowledge by reducing knowledge to the status of a tool.

Secondly, although the curriculum suggests the correct view that learning is an active and self-directed process, significant remnants of what Popper termed the bucket theory of mind can still be found. This theory misconceives the human mind as a vessel and learning as the transmission of knowledge and skills, akin to pouring knowledge faithfully from one vessel into another.

Most significantly, the curriculum presents an internal contradiction between its stated goal of maximizing learner autonomy and self-directed learning and its almost full commitment to centralized educational planning. As a result, handing down rigid competence descriptions as mandatory educational outcomes inevitably imposes severe restrictions on autonomy at all levels of the educational system, including schools, teachers, and, most importantly, students. By restricting autonomy and requiring teachers to transmit planned educational content faithfully, the curriculum limits and inhibits creativity on the part of both teachers and learners. Consequently,

such limitations on autonomy lead to a significant restriction of the most important resource of learning: the critical imagination of students.

This leads first to general and then to specific Neo-Popperian suggestions for improving the educational paradigm of the curriculum. The first general suggestion is a paradigm shift away from rigidity towards actual problem orientation. This would represent an enhancement to competence-oriented pedagogy, which, instead of truly viewing problems and their solutions as paramount, focuses on the formulation and acquisition of specific abilities that have not been chosen by the students. The second general point is connected to the paradigm shift towards problem orientation through the reconceptualization of educational outcomes. In line with fulfilling the curricular demand for individuation and the self-direction aspect of learning, the curriculum would benefit from conceptualizing the educational process not as a catalogue of facts or skills to be acquired but as a problem landscape to be explored by students autonomously with educational support. These general suggestions are also reflected in the specific suggestions with respect to the curricular understanding of knowledge, learning, and teaching.

Starting with knowledge, Neo-Popperian epistemology insists that knowledge is not an externally transferred collection of competences because no direct transfer of knowledge or the immediate adoption of a problem is possible. Instead, all problems have to be created by students by means of guessing, as a consequence of an interesting conflict between ideas. Knowledge, according to Popperian theory, is never justified in the sense that it rests on a firm foundation or indeed has authority. It rejects all claims to authority, which importantly includes the maxim that theories must be judged by their merit instead of their origin. Moreover, knowledge is always fallible, and humans are fallible knowledge creators. This means that one can expect errors in all theories, which presents opportunities for progress by way of criticism. Additionally, knowledge is an abstract entity in the sense that it can be conceptualized as information with causal power. All knowledge, in some capacity, corresponds to objective and absolute truth; however, achieving certainty about having attained absolute truth is impossible, as there is no truth criterion. Lastly, objective knowledge can be achieved through consistent fallibilism, which avoids both dogmatism and

relativism by implying truth without certainty and promoting progress through error correction.

Proceeding from the Neo-Popperian conception of knowledge, suggestions for learning—or the creation of knowledge in the context of the curriculum—can be divided into two central questions: *How is learning achieved?* and *What is to be learned?*

The Popperian answer to the first question is that the creation of knowledge can only take place through problem-solving. Problem-solving entails the formulation of a problem by becoming conscious of conflicting ideas, including expectations that are contradicted by experience. In response to the problem, the learner conjectures solutions and, crucially, identifies and eliminates errors to resolve contradictions. The process of solving a problem always leads to new problems. In this context, learning is and remains an open-ended process, progressing from problems to better problems and always involving the creation of good explanations.

To answer the second question—*What is to be learned?*—Neo-Popperian theory suggests formulating a general problem-solving competence informed by the Popperian problem-solving schema. Problem-solving competence, in essence, represents a meta-competence encompassing the relevant aspects of solving any type of problem, whether theoretical or practical. It entails three aspects of the Popperian problem-solving schema: the ability to 1) formulate problems, 2) conjecture possible solutions, and 3) identify and eliminate errors. The advantage of this approach lies in its generality: it replaces rigid, predefined competence descriptors with a more flexible framework, enabling students to learn in a self-directed manner. By adopting a generalized competence schema, learner autonomy can be achieved across three dimensions—topical, methodological, and social—allowing for interest-led exploration of the problem landscape through self-directed inquiry.

The final area of this project focused on outlining key aspects of a Popperian didactic within the Austrian educational context. Such an approach aligns with the educational goals specified by the curriculum, namely the development of autonomy and self-directed learning. Furthermore, it complements key aspects of competence-oriented pedagogy, such as its emphasis on problem-solving and fostering critical thinking in

students. In line with a paradigm shift towards problem orientation, the focus of teaching must, first and foremost, be to assist students in formulating and solving problems. Popperian teaching, therefore, aims to provide students with educational support free from coercion. Two essential methods of teaching in this framework are negotiation and educational provocation.

The goal of the educational process is not primarily the faithful transmission of traditional memes—such as enabling students to recite the most recent theories in their respective subjects. Instead, the process should focus on criticizing and rejecting anti-rational memes—cultural replicators that suppress students' critical faculties. In this context, tradition should neither be rejected outright nor embraced uncritically. Rather, traditional knowledge—such as textbooks and common sense—should be seen as valuable but fallible guides for navigating the problem landscape.

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