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Vital Cognitive Skills for Undergraduates Based on Academic Discipline: A Literature Review

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Abstract

The society is becoming more complex and science based, therefore, lots of efforts are directed to reform science education. This literature review aims at identifying the most crucial cognitive skills required for higher-education students to acquire based on their academic discipline. It would pay special attention to higher-order cognitive skills. Similar studies are concerned with school students and consequently targeting lower-order cognitive skills. Most of the studies concerned with higher-education students only focused on a specific scientific discipline. This paper would provide detailed data about vital cognitive skills for students in higher education phase targeting main academic disciplines: science and technology, health sciences and humanities sciences educational disciplines. 30 research papers in different educational disciplines have been reviewed and analyzed to include their results in this review. The reviewed studies' methodology varied between surveying experts' opinions, analysis of exam questions, redesigning course structure, applying problem solving tests, comparing results of pre-tests and post-tests. This review concluded that mastering science process skills in addition to spatial ability skills is essential for science and technology students. For health sciences, problem solving skills are of the fundamentals of the clinical competency of a medical practitioner. For humanities sciences, critical thinking skills came as the most crucial skills for this discipline's students.

Keywords: higher-order cognitive skills; higher education; science and technology; health sciences; humanities sciences

Introduction

The education community is paying considerable concern to promote higher-order cognitive skills through the higher education stage. The aim is for students to cope with the continuously changing rhythm of the surrounding world (Zhang, 2022). During higher education stage, students are supposed to turn into "better thinkers" with a desire and intention to learn more. They have to be able to face various life challenges. This is a solid concept believed and found in unlimited number of studies of different eras illustrating what to be gained through the higher education phase. The studies carried out by Laird (2014), Young (2014), Berkowitz (2018), and Casagrand (2017) have paid attention to the importance of students' thinking development through the higher education phase. However; it is not a general result for all undergraduates, the amount of progress and experience is not equal for all students (Laird, et al., 2014). A student could acquire and develop various skills such as social, physical, and emotional skills. However, cognitive skills are among the most important gains that higher education students achieve during university years due to its wide range of applicability across various educational disciplines.

Cognitive skills might be defined in various terms differing in concept and application, one of the concepts refers to cognitive skills as the ability to acquire general intellectual competencies and skills that are not necessarily related to specific curriculum or study area, though, are thought to be distinguished outcome of the higher education stage (Young, et al., 2015). According to many education theories, cognitive skills are not all of the same level of complexity, they are hierarchical from the simplest to the most complex skills in 2 main categories: lower-order and higher-order. Lower-order cognitive skills are required for students of all ages; however, they are more important for younger school students. But for undergraduate students, higher-order cognitive skills are considered of more importance as they are shaping their thinking skills for the upcoming professional and social lives, therefore, this research would focus more on this category of cognitive skills (Dresner, et al., 2014) & (Casagrand & Semsar, 2017).

Aim of the research

Large volumes of literature have covered the issue of identifying crucial and common cognitive skills critically needed for students of all ages. However, the research gap aimed to be covered through this study could be summarized in two points: 1) Similar literature reviews are available richly for school students

and consequently, more concerned with lower-order cognitive skills than higher-order cognitive skills, and 2) The majority of similar research work concerned with higher-education students is focusing on specific academic discipline. The primary aim of this review was to identify and accumulate the most crucial cognitive skills required for each academic discipline of the three main disciplines in a single research work. Science and technology, Health sciences education, and Humanities sciences could represent a sum of the present main educational disciplines.

Methodology

The present study has been carried out according to the following steps: searching, screening, full text retrieval, data extraction, reporting (Lyons, et al., 2017). A conventional manual review was conducted in multiple sources including scientific journals and conference proceedings. Various scientific databases including ScienceDirect, PubMed, and Google Scholar were searched to retrieve the most relevant research work about cognitive skills of high importance for each academic discipline. At first, the search has been carried out using the following terms: “cognitive skills higher education” “higher-order cognitive skills”, “cognitive skills for undergraduates”, “post-secondary cognitive skills”, “Bloom’s taxonomy”, “modern education” as well as searching by different combinations of terms including specific educational discipline such as: “nursing”, “medicine”, “social sciences”, “STEM courses “, “engineering”, and “technology”. A total number of 55 papers were saved for further screening, the abstract section was reviewed for all papers. So as to direct this review to the targeted domain, irrelevant research papers were excluded. After excluding irrelevant studies, deep and full review of the included studies was done to 30 papers followed by conducting a qualitative analysis of the content.

Cognitive skills in higher education: Background

The umbrella of cognitive skills encompasses many definitions or approaches including critical thinking, problem solving, reflective thinking, metacognition (Young, et al., 2015). Cognitive skills in order to be assessed, are supposed to be classified from basic simple skills to more advanced and complicated skills. Bloom’s taxonomy is a broadly accepted and reliable classification for the assessment levels of cognitive domain from lower-order to higher-order thinking skills. Six levels of understanding could be identified according to Bloom as follows: knowledge/remember, comprehension/understand,

application/apply, analysis/analyze, synthesis/create, and evaluation/evaluate. The first two levels at the bottom of the pyramid present lower-order cognitive skills LOCS while the following four levels present higher-order cognitive skills including: apply, analyse, evaluate, and create as shown in (Figure 1) (Casagrand & Semsar, 2017) & (Anderson , et al., 2000)

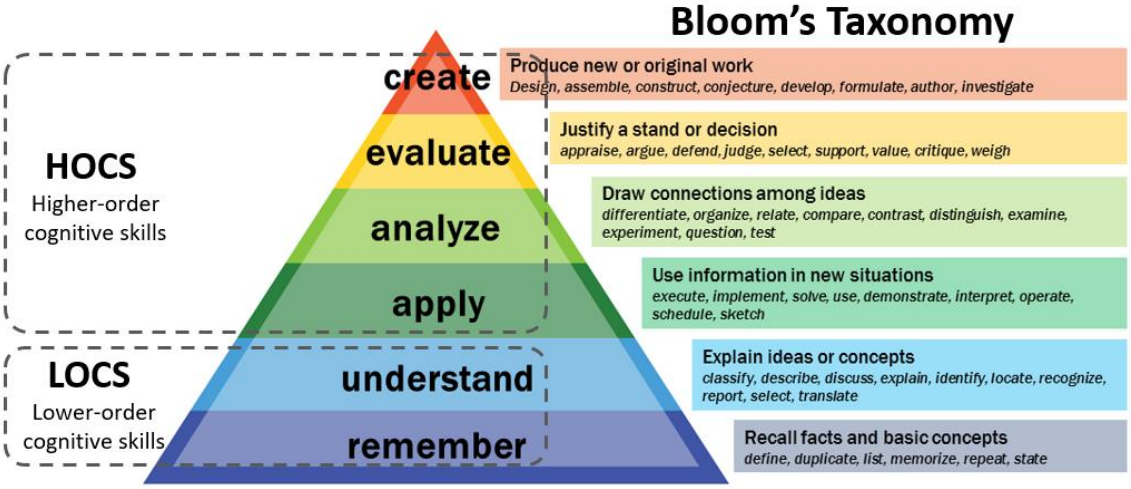

Figure 1. Bloom's revised taxonomy (Anderson, et al., 2000).

Students with lower-order cognitive skills could be described as those whose capability to solve questions requiring higher-order cognitive skills is lower than their capability to solve questions requiring lower-order cognitive skills by 15% or more. Students with higher-order cognitive skills are defined as those who can pass more than of 65% of questions in an examination requiring higher-order cognitive skills. The examination item is not limited to a question, it could be an exercise, a problem, a question, or a group of questions. Lower-order cognitive skills and higher-order cognitive skills items are defined as follows (Chandio, Zafar, & Solangi, 2021):

Lower-order cognitive skills items:

Knowledge questions simply require recall of familiar information or slight application of already known theory or situation. LOCS items could be problems /computational exercises solvable by previously taught/known/practiced procedures, but not necessarily understood.

Higher-order cognitive skills items:

Qualitative conceptual questions or quantitative problems that are novel to the student, solvable by more than simple knowledge or application of known procedures. Analysis, synthesis, critical thinking, problem solving, decision making, and evaluative thinking skills are required to solve these items. It also

could be solved by applying familiar knowledge or theory to unfamiliar situation or context.

Higher-Order Cognitive Skills

Through higher education phase, students are expected to develop their higher-order thinking skills in addition to gaining knowledge. Those skills facilitate dealing with daily life problems, moreover they optimize the use of acquired knowledge in the professional life. Figure (2) demonstrates actions or skills related to each level of cognition according to Bloom's taxonomy. Having an adequate critical thinking is requisite to develop higher-order cognitive skills. Therefore, institutions with instructional goal to enhance students' higher-order cognitive skills have to adopt learning and teaching practices promoting critical thinking (Petchtone & Chaijaroen, 2012). Other vital higher-order cognitive skills capabilities for the contemporary education approach are problem solving, decision making, and question asking. All of the aforementioned skills rely on evaluative thinking as a requirement, they are also considered as most important learning outcomes for undergraduates (Lemons & Lemons, 2013). Various studies were carried out to assess: 1) instructors' knowledge of higher-order cognitive skills, 2) to what extend higher-order cognitive skills are included in the course objectives, and 3) which courses actually apply teaching and learning practices promoting them. The majority of these studies concludes that although instructors acknowledge that higher-order cognitive skills are of the course objectives, only few courses actually applies teaching methods with this objective in mind. It was concluded that the matching between the instructor's intention to apply higher-order cognitive skills within studied course and the type of assessment practices was missing. One of the most successful approaches to aid students developing their higher-order cognitive skills is using those skills' related questions regularly through the course work. The type of questioning the instructor uses most is found to direct students' approach to the course work, if they get used to higher-order cognitive skills questioning, they would go deeper to understand course material rather than memorizing it. It has been noticed that exams asking mainly for memorization of volumes of materials succeeded in deviating students from deep understanding the course content (Lemons & Lemons, 2013), (Chandio, Zafar, & Solangi, 2021) & (Abosalem, 2016).

When studying factors contributing to cognitive skills development, many studies have identified college attendance, academic involvement,

interaction between student and staff members, service involvement, and peer interaction. Broad spectrum of studies agrees that attendance itself might promote the development of cognitive skills and especially critical thinking. This development could be translated into ability to answer harder questions and flexibility in accepting and understanding the other's opinions (Young, et al., 2015).

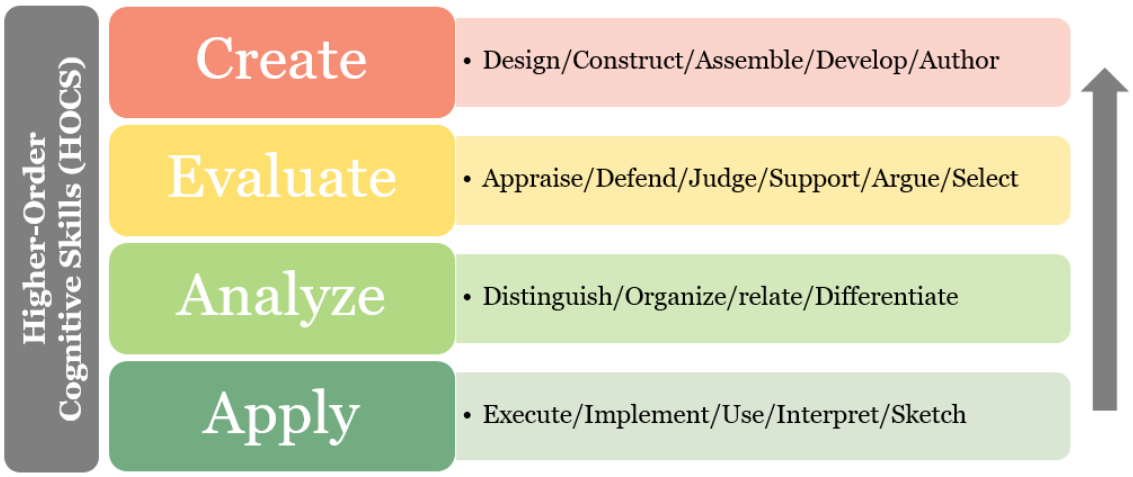

Figure 2. Higher-order cognitive skills (by author)

Science, technology, engineering, and math (STEM) educational discipline

Contemporary science and technology education is more relying on the "learning center" as a learning process or style. Primary aim of the learning center is encouraging learners to gain knowledge and accomplish goals on their own. Teaching and learning in this educational discipline demands for problem solving, discovery learning and active enquiry (Petchtone & Chaijaroen, 2012). The methodology of the reviewed studies varied between surveying education experts' opinions and analysis of specified general exams, and comparing results of pre and post exams for using a certain method. The sample size in the reviewed studies varied between 48 and 1352 participants.

According to Morrison (2006), the Founder and CEO of the Teaching Institute for Excellence in STEM (TIES) in her published report, questioning is the base of the development of problem solving skills the Teaching Institution for Excellence in STEM (TIES), questioning is the base of the development of problem-solving skills as "why" is the tool for understanding, building robust knowledge. The report published the institution have demonstrated the favoured attributes of a STEM educated student are being: 1) problem solver, 2) innovator, 3) inventor, 4) self-reliant, and 5) logical thinker.

Khlaisang & Likhitdamrongkiat (2015) have performed a survey study to collect opinions of 400 higher education instructors under the Office of Higher Education Commission in Thailand about the priorities of cognitive skills for each discipline. For science and technology, scientific process, systematic thinking, and analytical thinking came at the top of the list.

Berkowitz & Stern (2018) have focused in their study on the spatial ability (SA) and the reasoning ability as cognitive development factors for STEM students. Numerous studies suggested that spatial ability is considered a key factor for success in STEM discipline. Spatial ability (SA) in a general meaning refers to "the ability to generate, retain, and manipulate abstract visual images". Spatial ability combines many types but for the scope of STEM courses, spatial visualization (SV) is considered the most related type. Spatial visualization is in addition to the general definition of (SA), the ability to "apprehend a spatial form, shape or scene in order to match it with another spatial form, shape or scene, often with the necessity of rotating it in two or three dimensions one or more times". The methodology of this study is based on assessing several measures of verbal reasoning, numerical reasoning, and Spatial visualization of students from two different STEM program. The results concluded that spatial visualization had resulted in noticeable development for engineering technical drawing course while verbal and numerical reasoning ability skills had uniquely affected the achievement in most advanced math and physics courses.

Irwanto, et al. (2018) aimed in this research to investigate the impact of applying the process-oriented guided inquiry learning (POGIL) teaching method on critical thinking and problem-solving skills. POGIL is a teaching strategy developed to improve student performance and involve higher-order thinking skills. This quasi-experiment depended on comparing the results of pre-tests and post-tests of Critical Thinking Essay Test (CTET) and Problem-Solving Essay Test (PSET) for 2 student groups in the science education department before and after applying POGIL method in one of them. The results have revealed that critical thinking and problem solving are of the ultimate skills for science education students to acquire, it was also found that POGIL teaching method is capable of promoting these skills.

Harahap, et al. (2019) aimed in this research to figure out the effect of blended learning strategy on students' science process skills. Blended learning could be defined as the combination of web-based and face to face learning methods. It has been agreed by numerous researchers that science process skills

are those facilitating learning in physical sciences; moreover, shaping and reflecting the behaviour of scientists. This behaviour includes various skills such as observing, interpreting, classifying, asking, making hypothesis, predicting, and implementing concepts. Blended learning was found to noticeably enhance science process skills. By comparing the results of pre-tests and post-tests of 2 classrooms after applying blended learning in one of them, blended learning achieved significant effect in developing science process skills for biology program students in the Medan State University.

Table 1. Cognitive skills in science, technology, engineering, and mathematics (STEM) courses.

Author	Method	Findings
(Morrison, 2006)	Literature review Survey study	Problem solving
(Khlaisang & Likhitdamrongkiat, 2015)	Surveying opinions of 400 education experts.	Scientific process Systematic thinking Analytical thinking
(Berkowitz & Stern, 2018)	Assessing students' verbal reasoning, numerical reasoning, and Spatial visualization (SV).	Spatial ability
(Irwanto, Saputro, Rohaeti, & Prodjosantoso, 2018)	Comparing test results of 2 groups	Critical thinking Problem solving
(Harahap, Nasution, & Manurung, 2019)	comparing the results of pre-tests and post-tests of 2 classrooms after applying blended learning in one of them.	Science process skills
(Maison, Darmaji, Astalini, Kurniawan, & Indrawati, 2019)	Quantitative analysis of questionnaires and observation sheets for physics department students.	Science process skills
(Li & Wang, 2021)	A qualitative literature review.	Spatial cognitive process

Maison, et al. (2019) have carried out a quantitative research using questionnaires and observation sheets for physics department students to assess science process skills. Science process skills was agreed to be vital for students, lecturers, and scientists. Those skills are required for solving problems, studying, and conducting investigations. Science process skills were found to be of high importance for enhancing achievement in physics courses; however, the actual test scores in this study reveal that students' levels in Jambi University are still below average for these skills. (Table 1) summarizes the conclusion of related research studies concerned with vital cognitive skills required for the learners of this educational discipline.

Li & Wang (2021) have investigated the spatial cognitive process within STEM students and its important role in STEM education. They had applied a spatial navigation test on 194 cinese university students. the results of the test have revealed that each branch of the STEM education uses -and depends- on different spatial cognitive processes. For science and mathematics education, internal self-motivation cues had a noticable significance while for technology and engineering education, external guidance cues were more relied on.

Health sciences educational discipline

Health sciences as a main educational discipline is facing substantial transformations due to the changes of the health care delivery system. These changes are considered a sufficient cause for the community of the medical education to revaluate teaching methods and learning styles as well as the whole process of the medical education. Latest updates of the learning and teaching theories could provide medical field members with the best teaching and learning practices so as to meet the aimed learning outcomes represented in: 1) gaining required knowledge, skills and attitudes to completely and safely perform professional medical tasks and 2) development and refinement of the clinical skills required to deliver adequate care throughout the lifetime profession (Patel, et al., 2008). The methodology of the reviewed studies varied between the analysis of different question types in course exams, surveying education experts' opinions, redesigning curriculum content, and qualitative literature review. The sample size of the reviewed papers varied between 181 and 400 participants.

Palmer & Devitt (2007) have designed a study aiming to assess how modified essay questions affect higher-order cognitive skills in higher education. They have analyzed the ability of the question to enhance higher-

order cognitive skills for 2 types of questions including 50 multiple-choice questions (MCQs) and 139 modified essay questions (MEQs) of a summative assessment in a clinical undergraduate course. The results of the study showed that more than half of the analyzed questions only stimulated recalling. They concluded that synthesis, evaluation, and problem-solving skills are of the fundamentals of the clinical competency of a medical practitioner. this explains why these skills have to be taught and assessed through the higher education study.

Khan & Aljarallah (2011) have followed the same methodology in their study by analyzing two types of questions including 50 multiple-choice questions (MCQs) and 50 modified essay questions (MEQs) of the examinations delivered to fourth year medical students. Questions were categorized to different levels of Bloom's cognitive domain. It was concluded that problem solving skills are vital for medical education and gets special emphasis on learning and assessment as the physician spends most of time diagnosing patient's complaints.

Khlaisang & Likhitdamrongkiat (2015) have performed a survey study to collect opinions of 400 higher education instructors under the Office of Higher Education Commission in Thailand about the priorities of cognitive skills for each discipline. For health sciences education, systematic thinking, analytical thinking, and application are at the top of the reported cognitive skills required for this discipline.

Casagrand & Semsar (2017) redesigned a curriculum content to enhance Students' higher-order cognitive thinking skills from goals and mechanics to student outcomes. For health sciences courses, it was found that developing discipline-relevant problem-solving skills and integrating conceptual knowledge are vital levels of the cognitive domain required for this discipline students.

Lyons, et al. (2017) focused on cognitive apprenticeship theory in health sciences through a qualitative literature review and specially how to develop expert thinking. Expert thinking skill was concluded by numerous studies to be a vital component of the cognitive process that is supposed to be more focused on in health related courses. The following table (Table 2) summarizes the conclusion of focused research works studying crucial cognitive skills for the discipline of medical education.

Weidman & Salisbury (2020) aimed at analyzing the current state of critical thinking in the health sciences educational discipline in their literature review. The analysis of critical thinking comprised of the importance of thee

skills for this discipline, critical thinking frameworks, evaluation and discription methodologies, and evaluation tools. the focus of the study was on the sonography major. Critical thinking was reported to have a significant importance for sonography students as they have to think intuitively and analytically so as to provide the best care and accurate diagnosis. However, there is still a shortage in the reliable and valid asesment tools that educators could use to evaluate the students' critical thinking skills.

Jafari et al. (2020) have carried out this systematic review to summarize the materials and methods of the research studies related to critical thinking skills of helath sciences students in Iran and to evaluate the level of critical thinking skills of the Iranian medical sciences students. the results have shown that the level of students' critical thinking skills was relatively low and promoting strategies is urgently needed. Effective teaching methods and training courses is beneficial to be adopted due to the necessity and importance of critical thinking for health sciences education students.

Table 2. Cognitive skills in health sciences education.

Author	Method	Findings
(Palmer & Devitt, 2007)	Analysis of MCQ and MEQ questions	Synthesis Evaluation Problem-solving
(Khan & Aljarallah, 2011)	Analysis of MCQ and MEQ questions	Problem solving
(Khlaisang & Likhitdamrongkiat, 2015)	Surveying opinions of 400 education experts.	Systematic thinking Analytical thinking Application
(Casagrand & Semsar, 2017)	Redesigning a curriculum content	Problem-solving Integrating conceptual knowledge
(Lyons, McLaughlin, Khanova, & Roth, 2017)	A qualitative literature review.	Expert thinking
(Weidman & Salisbury, 2020)	A qualitative literature review.	Critical thinking
(Jafari, Azizi, Soroush, & Khatony, 2020)	Systematic review	Critical thinking

Humanities sciences educational discipline

According to Anderson and Krathwohl, learning could be divided according to the intended goal into 2 approaches: learning for retention and learning for transfer. Learning for retention could be described as a fridge storing plenty of meanings for further use; however, learning for transfer is when one chooses and decides which meaning has to be used in a certain emergency situation. As an undergraduate engaged in this education discipline, affective and meaningful learning is that equipping students with tools needed to do transfer (Zamani & Rezvani, 2015). The methodology of the reviewed studies varied between surveying education experts' opinions and analysis of specified general exams. The sample size varied between 35 and 400 participants.

Athanassiou & McNett (2003) have discussed in their study the use of Bloom's taxonomy in the management class to build students' critical thinking as well as synthesis skills. The adopted method was evaluating group and individual class assignments according to a checklist based on the hierarchy of Bloom's taxonomy cognitive levels. The results revealed that critical thinking skills are urgently demanding for further development to enable students build their responsibility and increase their control over the learning process as the present levels of students' achievement are dissatisfying.

Thomas (2011) proposed that critical thinking could be and has to be introduced to the first year or higher education so as to enhance students with the required tools for the rest of that education phase. Critical thinking was assessed through critical thinking activities workshop for students from different universities. As a conclusion, critical thinking has been identified as a key skill and one of the most desirable attributes of higher education graduates, it has to be introduced and developed in the 1st. year so as to provide students with the fundamental tools needed through the rest of the program and afterwards.

Khlaisang & Likhitdamrongkiat (2015) have performed a survey study to collect opinions of 400 higher education instructors under the Office of Higher Education Commission in Thailand about the priorities of cognitive skills for each discipline. The results showed that for humanities sciences education, the most 3 desirable skills for students to acquire were creative thinking, analytical thinking, and systematic thinking. (**Error! Reference source not found.**) summarizes the conclusion of focused research studies concerned with vital

cognitive skills required for the learners of the humanities sciences educational discipline.

Table 3. Cognitive skills in humanities sciences

Author	Method	Findings
(Athanassiou & McNett, 2003)	Evaluating group and individual class assignments	Critical thinking
(Thomas, 2011)	Assessing critical thinking through activities workshop	Critical thinking
(Khlaisang & Likhitdamrongkiat, 2015)	Surveying opinions of 400 education experts.	Creative thinking Analytical thinking Systematic thinking

Interfered Cognitive Skills

Educators are not the only community concerned with the importance of higher-order cognitive skills. Researchers and policymakers higher-order cognitive skills emphasize the need for undergraduates to acquire at least a moderate level of higher-order cognitive skills. Regardless of the educational discipline, it has been argued that higher-order cognitive skills are of the 21st. Century skills that youth need to be ready and prepared for the future (Lu, et al., 2021).

Huffman, et al. (2000) have conducted a survey study to collect data from 51 students aside by a descriptive literature review to figure out whether critical thinking skills are valued in the educational system. The results provided strong evidence that critical thinking is considered a skill of high value across all disciplines in the educational system. Students' own words have supported the belief that a link exists between teaching and involving critical thinking inside classrooms and students' experiences in the real life.

The descriptive literature review by (Petchtone & Chaijaroen, 2012) aimed at developing a web-based learning model to improve undergraduates' higher-order cognitive skills. Collected data included expert reviews in various fields including and not limited to education, media, critical thinking, constructivist learning environments, and evaluation experts. It was concluded that extending critical thinking skills through the educational process, for both teaching and learning, is the key to develop students' higher-order cognitive skills.

(Klegeris, et al., 2019) aimed at assessing problem solving skills for 600 higher education students as these skills were reported to be one of the most employability skills in current workplaces. A simplified version of the certified PISA problem solving tests was administered by the researchers for students over the first 3 years. The findings of the study revealed 2 main observations. First, problem solving and critical thinking are of the crucial skills for undergraduates; However, were found to be lacking in the recent higher education graduates. Second, significant improvement in the test scores was noticed when it was first administered in the first year and once again the third year.

In the report published by the higher education quality council of Ontario, an assessment of the basic cognitive skills has taken place for students ranging from admission to graduation. Critical thinking was embedded seamlessly in course assignments using the VALUE rubrics. By comparing and analyzing pre-admission and post-admission test results, Literacy, critical thinking, and mathematics/numeracy have been marked as essential skills that a postgraduate must know and practice (Ingleton & Fricker, 2021). (Table 4) provides a summary for general cognitive skills required for students across all educational disciplines.

Table 4. Interfered cognitive skills across all disciplines.

Author	Method	Findings
(Huffman, Carson, & Simonds, 2000)	Literature review and survey study	Critical thinking
(Petchtone & Chaijaroen, 2012)	Literature review (descriptive study)	Critical thinking
(Klegeris, Dubois, Code, & Bradshaw, 2019)	Applying problem solving tests.	Problem solving Critical thinking
(Ingleton & Fricker, 2021)	Comparing and analyzing the results of pre-admission and post-admission tests.	Critical thinking Literacy Mathematics/numeracy

Conclusion

Extensive evidence is available that cognitive skills development through the higher education phase is what turns students into better thinkers with a developed mentality able to face their social and professional life afterwards.

Although abundant studies have revealed the importance of cognitive skills for undergraduates and specially those of higher order, many field studies have come to a conclusion that the majority of the teaching staff does not have enough awareness about: 1) the importance of higher-order skills, 2) how to teach them and use them inside the work environment, and 3) how to embed them in the curriculum and consider as a learning outcome. The results of this study conclude the top skills for each academic discipline as reviewed in the literature. For science and technology education, students have to master science process skills as these skills are facilitating learning physical sciences; moreover, are shaping the behaviour of scientists. Spatial ability and Problem solving also were mentioned as skills of high importance as it is urgent for science and technology students to become competent problem solvers. For health sciences education, problem solving skills are fundamental for the clinical competency of medical practitioners as they spend most of time diagnosing patients' complaints. In addition, systematic thinking, synthesis, and evaluation are vital components of the cognition of students in this discipline. For humanities sciences discipline, critical thinking came at the top of the list. It has been identified as the most desirable attributes of higher education graduates, it has been found to enable students build their responsibility and increase their control over the learning process. Besides critical thinking, creative thinking and analytical thinking are essential skills to facilitate studying social sciences. It has been agreed between the majority of reviewed studies that critical thinking skills are crucial for undergraduate students across all disciplines. (**Error! Reference source not found.**) summarizes the conclusion of the present study by framing discipline-based skills in addition to overlapped skills.

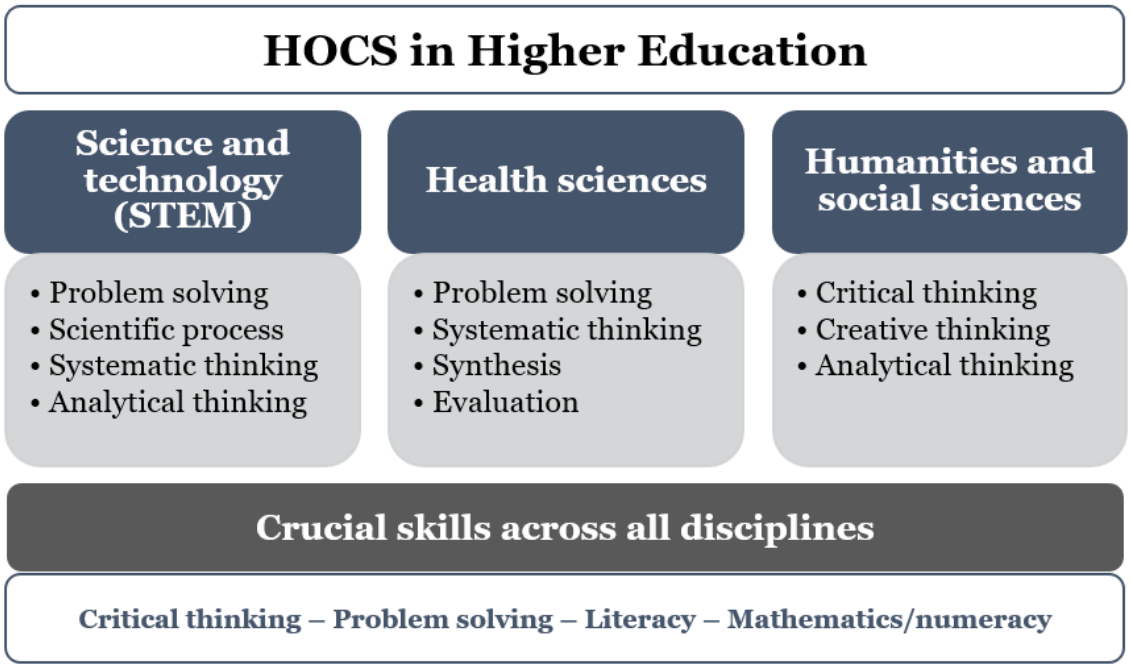

Figure 3. Conclusion of desired higher-order cognitive skills in higher education (by author)

It has also been concluded that introducing higher-order cognitive skills in the 1st. year of college reinforces students with the essential tools needed for efficient learning through the next years. As a step forward to stimulate and develop the acquisition of higher-order cognitive skills in college, various teaching and learning strategies were suggested and proven to be efficient. Blended learning, POGIL strategy, smart classrooms environment, and peer interaction were mentioned repetitively in this context. For further research in this area, various teaching methods and trends to be deeply studied and analysed in order to figure out which teaching method could enhance developing certain cognitive skill. This would help curriculum creators to decide upon a matrix illustrating the most convenient teaching method when targeting a specific skill. Moreover, practical training and awareness about higher-order cognitive skill, what they are and how to be embedded in teaching environment have to be offered to the teaching staff.

Recommendations

It was intended by the present study to identify and combine the most considerable cognitive skills for undergraduates to acquire according to academic discipline in a single research work. The majority of previous studies in this scope relied on qualitative literature review, systematic review, and field survey as the research method. This study recommends future research to conduct skills assessment scales on students from different disciplines and

comparing the results. This would help formulating a clearer vision about the actual level of students' skills in each educational discipline and therefore, focusing on promoting the required skills.

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المهارات المعرفية الضرورية لطلاب التعليم العالى بناء على التخصص الدراسى: مراجعة أدبية

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المستخلص.

لقد أصبح المجتمع أكثر تعقيدًا وأكثر إعتمادًا على العلوم؛ لذا يتم توجيه الكثير من الجهود لإصلاح تعليم العلوم. تهدف هذه المراجعة الأدبية إلى تحديد المهارات المعرفية الأكثر أهمية التي يجب على الطلاب الجامعيين اكتسابها بناءً على تخصصهم الدراسى. توجه هذه الدراسة اهتمامًا خاصًا للمهارات المعرفية العليا. بمراجعة الدراسات المماثلة وجد أنها تهتم بطلاب المدارس و بالتالي تستهدف المهارات المعرفية الأساسية (الدنيا). و عند توافر ابحاث متعلقة بالطلاب الجامعيين، تكون مركزة فقط على تخصص علمي محدد. ستوفر هذه الورقة البحثية بيانات مفصلة حول المهارات الإدراكية العليا الأكثرأهمية لطلاب التعليم العالي فى التخصصات الدراسية الرئيسية: العلوم والتكنولوجيا والعلوم الصحية والعلوم الإنسانية. تم استعراض وتحليل ٣٠ بحثًا في مجالات تعليمية مختلفة لتضمين نتائجها في هذا المراجعة. تباينت منهجيات الدراسات التى تمت مراجعتها بين استطلاع آراء الخبراء، وتحليل أسئلة الامتحانات، وإعادة تصميم بنية المقررات الدراسية، وتطبيق اختبارات حل المشكلات، والمقارنة بين نتائج الاختبارات القبلية و البعدية بالدراسات التجريبية. استنتجت هذه المراجعة أن اتقان مهارات عملية العلوم بالإضافة إلى مهارات القدرة المكانية ضروري لطلاب العلوم والتكنولوجيا. أما بالنسبة لعلوم الصحة، فإن مهارات حل المشكلات تعتبر أساسية للكفاءة السريرية للممارس الطبي. وبالنسبة لعلوم الإنسان والاجتماع، فإن مهارات التفكير النقدي تعتبر الأكثر أهمية لطلاب هذا التخصص.