EDUCATION RESEARCH HIGHLIGHTS IN MATHEMATICS, SCIENCE AND TECHNOLOGY 2020

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Address
Istanbul C. Cengaver S. No 2 Karatay/Konya/TURKEY

E-mail
isresoffice@gmail.com

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SECTION 2: MATHEMATICS EDUCATION

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SECTION 1
EDUCATIONAL TECHNOLOGY

Gamification of Education: Usage of Game Mechanics to Enhance the Learner Knowledge Adoption

Marko Suvajdzic
University of Florida
Dragana Stojanovic
Singidunum University

Gamification is the application of game-design elements and game principles in non-game contexts. Through the gamification of education, technology is working on improving and scaling education. Video games allow for individual participation of all learners, and thus are a valuable tool in the system of education. Furthermore, the emergence of gamification of learning is one of the major results of the increased use of technology in education.

Games have been used as a form of entertainment, as well as a tool for learning, for thousands of years. The increased sophistication of video games provides for improved entertainment experience, and an increased ability for players to retain the information communicated during a game. While some games are created with the goal of educating, the vast majority of games are created for entertainment purposes only. However, regardless of the intent behind their creation, the learning process takes place, whether it is intentional or not. The only difference is in what is being learned, and how that new knowledge is perceived and categorized in the player's mind.

The early evidence, both anecdotal as well as scientific, suggests that interactive virtual environments work. Based on this initial research, it seems as if interactive virtual environments are changing the way in which we learn, and that those exposed to it are having measurable and concrete increase in academic scores.

Through the use of such tools, young people are engaged in an exploration of language, games, social interaction, and self-directed education that can be used to support learning. They are different as a result of this use of digital media, and these differences are reflected in their sense of self, in how they express their independence and creativity, and in their ability to learn, exercise judgment, and think systemically.

Earlier Debates: Media in Education

Speaking of media and technology usage in the process of education, teaching and learning, we must go back to some of the early discussions of this fusion and its potentials. Much of the discussion about the role of virtual worlds, gaming and IT in education today is reminiscent of the conversations that have happened earlier in the 20th century on the topic of education and media. Certainly, there were always those educators who claimed that gamification, distance education or learning within virtual worlds is the best way to learn. However, most who have studied the impact of technology on education would agree that all of these different approaches make but only a part of the whole that goes into the process of transferring knowledge, and that such options are just but the few that would be available to a learner at any given moment. Speaking in the terms of gamification in education, and looking at the research results from previous decade,[1] we can conclude, even with all the challenges to be met in the future times, that gamification can certainly lead to much better results both for the students and educators regarding the process of learning, remembering and feeling involved. However, it is important to note that it can give its best effect if combined with other educational methods. Of course, in order for this fusion to be fruitful, both traditional teaching methodology and gamification learning strategies have to work in cooperation. It means that we need more teachers/mentors who would opt for gamification in education, and, on the other side, more video game programmers who would see the field of education as an exciting new terrain for development. A different way to look at the role of technology in education is to not focus on its direct role as a benefit, but to evaluate the changes that such a shift will bring, and the secondary opportunities that will be born out of such a change.

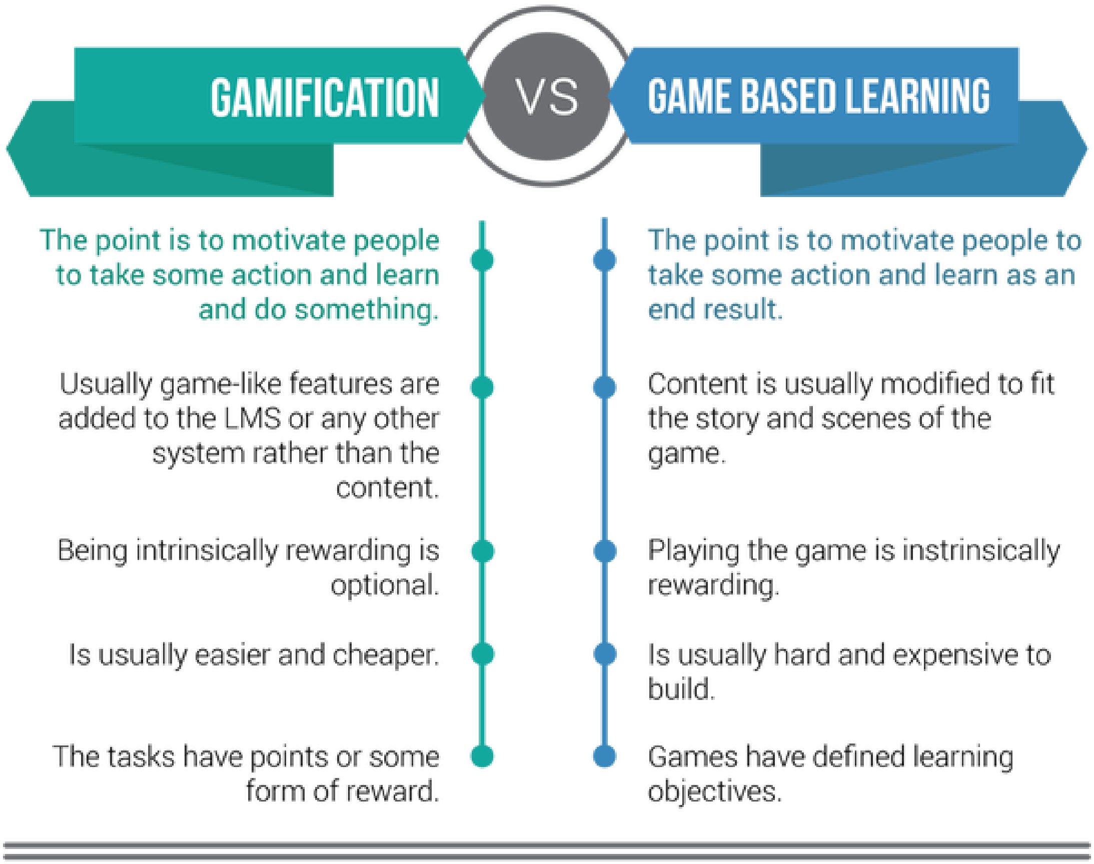
Looking back to some of the thoughts in this area from the second part of the 20th century, we can find Richard Clark's seminal work from 1983, containing now famous "mere vehicles" analogy: "The best current evidence is that media are mere vehicles that deliver instruction but do not influence student achievement any more than the truck that delivers our groceries causes changes in nutrition… only the content of the vehicle can influence achievement."[2]

The article went on to argue that instructional media is excellent for storing the knowledge, but it had little to no influence on the learning effect. Learning was not enhanced because the knowledge was media based, but rather it was fully dependent upon its own quality. Thus the role of media was delegated to a subservent and frivolous role, and the author urged the academia to "give up your enthusiasm for media effects on learning", which was also a theme of one of his follow up publications.[3] His words became a rallying cry for those who opposed the value of media in education for years to come.

Another pioneer of learning technology and distance education Jim Finn from the

[1] See, for example, different but equally important conclusions in Dominguez, A. et al. (2013), Gamifying learning experiences: Practical implications and outcomes. *Computers & Education*, Volume 63, April 2013, Pages 380-392,
Biro, G. I. (2014). Didactics 2.0: a pedagogical analysis of gamification theory from a comparative perspective with special view to the components of learning. *Procedia - Social and Behavioral Sciences, 141*, 148–151, or Dichev, C. and Dicheva, D. (2017), Gamifying education: what is known, what is believed and what remains uncertain: a critical review, I*nternational Journal of Educational Technology in Higher Education* volume 14, Article number: 9 (2017), https://doi.org/10.1186/s41239-017-0042-5.
[2] Clark, R. E. (1983). Reconsidering research on learning from media. *Review of Educational Research, 53(4),* pg.445.
[3] Clark, R. (1994). Media will never influence learning. *Educational Technology Research and Development*, 42(2), 21-29, pg. 28.

University of Southern California compared the changes in education to the changes that another technology has created upon history. He often told the story that went like this: "The Anglo-Saxons, a dominating enemy of Charles Martel's Franks, had the stirrup but did not truly understand its implications for warfare. The stirrup made possible the emergence of a warrior called the knight who understood that the stirrup enabled the rider not only to keep his seat, but also to deliver a blow with a lance having the combined weight of the rider and charging horse. This simple concept permitted the Franks to conquer the Anglo-Saxons and change the face of the western civilization. Martel had a vision to seize the idea and to use it. He did not invent the stirrup, but knew how to use it purposefully."[4]



Finn summarized the implications of his story in the following terms: "The acceptance or rejection of an invention, or the extent to which its implications are realized if it is accepted, depends quite as much upon the condition of society, and upon the imagination of its leadership, as upon the nature of technological item itself… The Anglo-Saxons used the stirrup, but did not comprehend it; and for this they paid a fearful price… It was the Franks alone-presumably led by Charles Martel's genius – who fully grasped the possibilities inherent in the stirrup and created in terms of it a new type of warfare supported by a novel structure of a society that we call feudalism… For a thousand years feudal institutions bore the marks of their birth from the new military technologies of the eight century."[5]

[4] Finn, J. D. (1964) *The Franks had the right idea*. NEA Journal, Vol. 10. No.3.
[5] Ibid, pg. 24.

Like Clark, Finn puts forward that new technology in itself may not bring any specific advantage. However, he also proposes that it is not the technology itself that brings improvements, but that it's the specific usage of the new technology, and the new ways that are made possible by the specific technology that makes the difference. In his story, it was not the stirrup, but the knight that caused great changes in the society, and it was the stirrup that allowed the creation of the knight. In a similar vein, the virtual worlds, gamification and various other computer enabled technologies may not be the positive influence on education in themselves, but may be the building block that will allow for creation of new paradigms, that will bring about improvements that we cannot imagine from our current perspective.

Gamification: is the Teacher Present?

Gamification in education often implies an aspect of the learning process that might be worth considering: learning from a distance, which means partial or total lack of the physical presence of the teacher. Is gamification then a sort of distance learning technique?

Although the field of distance education has existed since the 1840s, the need for a theoretical base of distance education was still largely unfulfilled until the 1970s. Holmberg stated that the further theoretical considerations will provide for firm ground upon which further research will be conducted.[6] Moore, on the other hand, was concerned the future progress in the distance learning field will be hindered by the lack of macro factors. He indicated that in this area of education there was a need to describe and define the field, to discriminate between the various components of the field, and to identify the critical elements of the various forms of learning and teaching.[7] Keegan, some time earlier, reflected upon the theory of distance education and implied the continual need for its development of perfection: „Lack of accepted theory has weekend distance education: there has been a lack of identity, a sense of belonging to get the referee and the lack of a touchstone against which decisions on methods, one media, financing, student support, when they have to be made, can be made with confidence.“[8] Keegan elaborated on his ideas in regards to what the theory should encompass. According to Keegan, the theory should provide the firm ground against which decisions to be made. He stressed the importance of having clearly defined terminology, processes, and definitions. He believed that only with the firm base there can be further developments of distance education, especially in regards to the ad hoc approaches, that commonly plagued the field. It can all, as a method and a problem to be discussed, be applied to

[6] Holberg B. (1985) *The Feasibility of a theory of teaching for distance education and proposed theory.*(ZIFF Papier). Hagen, Westgermany: Fern Universitat, Zentrales Institute furFernstudienforschungArbeitsbereich. (ERIC Document Reproduction Service No. ED290013)
[7] Moore, M. (1994) *Autonomy and interdependence*.The American Journal of Distance Education, 8(2), 1-5.
[8] Keegan D. (1988) Theories of distance education: Introduction. In D. Stewart, D. Keegan & B. Holmberg (Eds.), *Distance education: International Perspective* (pp. 63-67). New York: Routledge, pg.63.

gamification issues in the field of education nowadays, which is why we would like to bring more opinions on the question of distance learning effectivity.

Following the mentioned path of thought, Holberg also suggested that the field of distance education has been characterized by trial and error approach.[9] He maintained that there was a lack of true theoretical work that can be used as a true guide in the development of distance education. While to many scholars, distance education represents the deviation from conventional education, Holberg argued that it was a distinct form of education from conventional education. Keegan agreed with such an approach, and he also concluded that distance education is a separate form of education from conventional education.[10] According to Wedemeyer, which might be important for both the theoretical and practical approach in using video games in the process of learning, the essence of distance education was the independence of the student.[11] This can be seen in his usage of the term *independent study* for distance education at the college or university level.[12] Wedemeyer has been very critical of contemporary patterns of higher education. He believed that many of methods and approaches were utilized, and that they failed to embrace and take advantage of monitors ologies in the ways they can alter the field of education and the perception of the institution. Wedemeyer defined the system with done characteristics that emphasize learner independence and adoption of technology as a way to implement that independence, and suggested separating teaching from learning as a way of breaking educations space-time barriers.Wedemeyer identified four elements of every teaching-learning situation: a teacher, a learner or learners, a communication system or mode, and something to be taught or learned. The most important aspect of this development in regards to the distance education he believed to be the *development* between the student and the teacher. In this light, we can start thinking about gamification in education as of the next phase of development of the communication system or mode in the process of learning, which would lead to a better development between the students and the teacher.

Also, with Keegan's concept of distance education we find the separation of the teaching acts in time and place from the learning acts.[13] Successful distance education, he believes, requires the reintegration of the two acts: the intersubjectivity of teacher and learner, in which learning from teaching occurs, has to be artificially re-created, and also, learning materials, both print and nonprint, are designed to achieve as many of the characteristics of interpersonal communication as possible. When courses are presented, reintegration of the teaching act is attempted by a variety of techniques, including communication by correspondence, telephone tutorial, online computer communication, comments on

[9] Holmberg, B. (1995) *The sphere of distance education revisited.* (ERIC Document Reproduction Service No. ED386578)
[10] Keegan, D. (1996) The foundations of distance education (3rd. ed). London: Croom Helm.
[11] Wedemeyer, C. (1981). Learning at the backdoor. Madison, WI: University of Wisconsin Press
[12] Ibid.
[13] Keegan, D. (1996) *The foundations of distance education* (3rd. ed). London: Croom Helm.

assignments by tutors orcomputers, and teleconferences. We would argue that adding gamification to this process, through using educational video games specifically designed to improve the course goals and curriculum, would logically continue this technological string through contemporary times.

Learning Online with Games, Simulations, and Virtual Worlds: Do Highly Interactive Virtual Environments work better?

Interactive environments are nothing new in the field of education. For decades, if not centuries, teachers have used short games to introduce difficult topics to students, and mock trials have been the staple at law schools for decades. In sports, athletes spend hundreds of hours practicing for every hour spent on the field. Recreating the world of competition in the form of games or mock play has been a staple of teaching practices for a long time. Some of those practices are light hearted, while some are intense and focused.

But, are the virtual worlds effective as the means of gaining knowledge? Are they just a current fad, or do they present the way of the future?

Here is one well documented example: researcher Kurt Squire tested a simulation/game called *Supercharged,* developed at MIT by John Belcher and Andrew Mckinney, to teach about electromagnetic forces. Using the pre- and post- tests with control groups, he found that the participants in the control group receiving interactive lectures improved their understanding by 15 percent over their pre-test scores, while those who played with the game improved their understanding by 28 percent.[14]

Gamification in Education Statistics

- 67% of students reported that a gamified course was more motivating than a traditional course.
- The 5 most popular gamification features in educational apps (which can also be used for corporate purposes) are progress bars, achievements, in-app currency, leaderboards, and actual games.
- Most preferred gamification strategies by adult learners are progressing to different levels (30%), points/scores (27%), real-time feedback on performance (26%), progress bars (25%), activity feeds (24%), competition with friends (13%), being part of a story (11%), avatars (3%), and virtual currencies (2%).
- Gamification affects the willingness of students to study enjoyably, with preferences for certain gamification elements: profile updates (53%), getting points (27.2%), receiving badges (14.1%), and other awards (5.4%).
- Gamification is one of the top 10 must-have features of a learning management system.

In another study, Dr. John Dunning, professor of Organizational Behavior at Troy University, discovered that students gave high marks to a course using tradional linear media. However, when he surveyed them six months later, the knowledge and

[14] Squire, K., M. Barnett, J.M. Grant, and T. Higginbotham. 2004. *Electromagnetism Supercharged! Learning Physics with Digital Simulation Games*. (Proceedings of the 2004 International Conference of the Learning Sciences). Los Angeles: UCLA Press.

theories learned were not being applied in the workplace. To test the use of simulation Dr. Dunning organized two different classes. One class used the traditional methods, based on case studies and term papers. The other class used the leadership simulation interactive simulation approach to learning. Six months later the students in the second class had a significantly greater occurances of being able to explain the material and, most importantly, being able to apply it.[15]

But Why Is This Happening?

Based on the studies conducted to date, there seems to be a consensus that the highly interactive virtual environments indeed do improve the learning process. However, it is still not clear why it is so. Here is a list of the different arguments, looking at the different components of interactivity.

Argument 1: Games as a Learning Tool

Games are the original learning tools. They have been around a lot longer than our modern classrooms. Our species has used games and simulations to pass on the knowledge since the dawn of humanity. Even today, law students sharpen their skills in mock trials, soldiers prepare for wars in mock battles, etc. Our forefather's way of teaching went mostly through this line:

- show how something is done;
- observe the student;
- correct the actions;
- allow the student to hone the skill through a series of exercises and games that motivate repetition and competition.

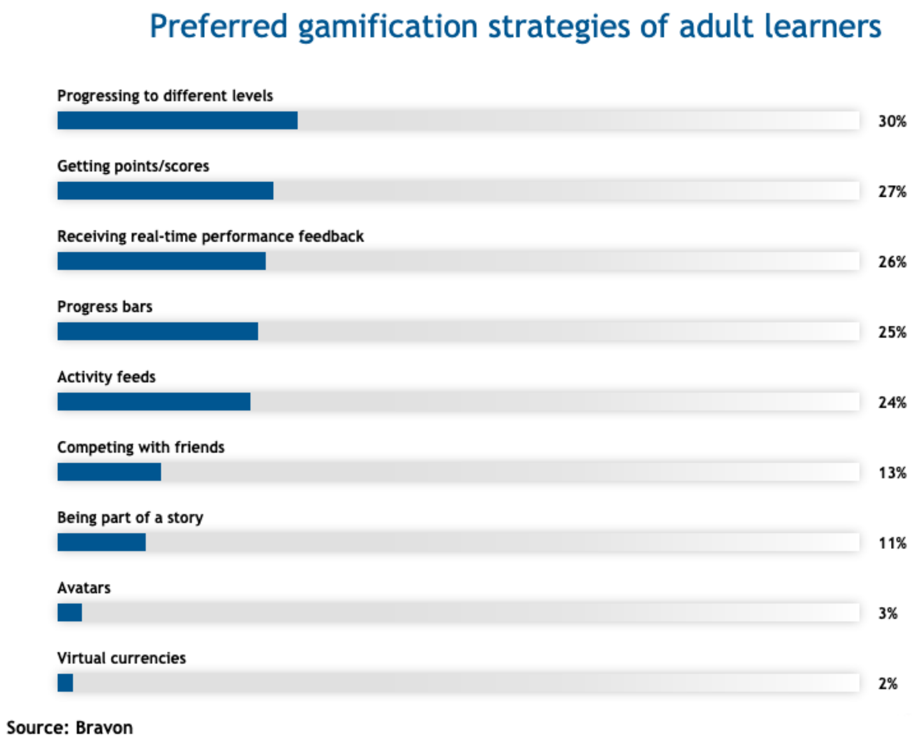
However, such approach is very difficult to scale. It requires a very low ratio between the teacher and the students, as otherwise the teacher is not capable of observing with necessary attention the performance of all his students. In the last two hundred years the number of students increased dramatically, and the traditional model of teaching was modified to fit the modern needs. So the model was changed into:

- talk about how something is done;
- students learn on their own;
- valuate with standardized tests.

Nowadays the technology is working on solving the challenge of scaling education. By

[15] Aldrich, C. 2009. *The Complete guide to simulations and serious games*. San Francisco: Jossey-Bass/ Pfeiffer.

utilizing games and virtual environments, coupled with advanced Artificial Intelligence, scientists are working on recreating the type of attention that the students of old have received, while being able to multiply it infinite number or times (as software can be installed on many machines).



Argument 2: Context and Emotional Involvement

Knowledge is useful only in context, and games and virtual environments provide the context, ideally similar to the context in which the knowledge will be eventually used.[16] For example, if we would like to teach a child about bullying in school, and how to best respond in such a situation, when stressed out and excited, it would be the best to recreate such scenarios, induce excitement, and allow the learner to play through various possibilities. This is exactly what games do, they recreate worlds and allow for player to identify himself with the virtual environments, thus providing context to any particular behavior.

When we have an emotional stake in the experience, only then our brain releases the chemicals in the amygdala and hippocampus necessary for memory.[17] It is our body's mechanism that decides what data is important and thus transformed into a memorized information versus which data is discarded. This is why it is easier for us to remember a good novel versus a bad textbook. In school we often learn the best when there is a fear present of the upcoming test. The very emotional involvement in these situations is what makes us remember better what we learned.

[16] Gee, J.P. 2003. *What video games have to teach us about learning and literacy*. New York: Palgrave/ Macmillan.
[17] Ledoux, J. 1998. *The emotional brain*. New York: Simon & Schuster.

In combining the context and emotional involvement, many have argued that failure is necessary to learn.[18] Thus creating teaching paradigms in which failure is safe is of the essence to education. Games are exactly such environments, which allow for experimentation and failure in a structured and safe format.

Argument 3: Participation

One can't learn to ride a bicycle from a great lecture, the saying goes. And what is true of riding a bicycle may be true of negotiating and strategizing, as well as other similar skills. Often the participation is a necessary ingredient in an experience, that makes us remember it afterwards. The process of converting experiential expertise into linear material such as books and lectures strips out most of what is valuable in the content to begin with.[19]

Many of us have experienced working in a group on a single computer, where on different occasions, different people would ask to take over the mouse and actively participate in creation. Or when a group of children plays a video game, often there is a desire in many of the individuals in the group to have the controller and play the game, simple watching it is not enough.

Video games allow for individual participation of all learners, and thus are a valuable tool in the system of education.

Interactive Video Gaming Content from the Students' and the Instructor's Perspective

Video games and virtual environments represent a fundamentally different approach to education from traditional learning. In analyzing the differences between the two approaches, we can divide them into three distinct categories:[20]

- How the differences in approach affect the content and its delivery
- How the differences in approach affect the teachers experience
- How the differences in approach affect the learners experience.

So far we have discussed the differences and their effect on the content, next we would like to focus on how these differences affect the teacher/learner experience. Among the

[18] Keith, N., and M. Frese. 2008. Effectivness of error management training: A meta-analysis. *Journal of Applied Psychology* 93, 59-69.
Klein, T.A., T.Endrass, N. Kathmann, J. Neumann, D.Y. von Cramon, and M. Ullsperger.2007. Neural correlates of error awareness. *Neuroimage* 34, 1774-1781.
[19] Aldrich, C. 2009. *The complete guide to simulations and serious games*. San Francisco: Jossey-Bass/Pfeiffer. Barrie, E. 2001. *Meaningful interpretative experiences from the participants perspective.* PhD diss., Indiana University.
[20] Aldrich, C. 2009. *Learning Online with Games, Simulations, and Virtual Worlds*. San Francisco: Jossey-Bass/Pfeiffer.

more obvious differences between the traditional classroom and the highly interactive environments are the new social rules and habits. Together they form a new culture that manifests itself within the practices related to interactive learning. Often these new cultural norms can be confusing or even frustrating to the newcomers, but they represent a fairly minor shift in the student's experience. The following examples illustrate these differences and their new practices.

(A)synchronous Communication

Each generation has its own ways, its own manners, and its own habits. Historically it has been expected that the lecturer will be presenting to an audience that is paying undivided attention. However in the highly interactive virtual/gaming worlds like Second Life it is normal for the audience to chat while attending a lecture. So while a professor may be talking to a hundred students in a virtual room, the students are all talking to each other in the same time. They are using chat to communicate with each other, while listening to the lecture. Most commonly, the chat is pre-created and serves the very purpose of giving the audience the ability to interact while the lecture is in session. Such an approach is normal in Second Life and thus it would be normal in gamification process, but it is still rare in the traditional classrooms.

So is it chaos? No, there are still rules and norms to follow. For example, it is considered rude to chat about topics that are not directly linked to the topic of the lecture. And since the chat windows are relatively small in size, it is perceived as improper to monopolize it. Monopolization can be done in few ways, one is to talk in very lengthy sentences and thus directly take over too much screen real estate. Another example would be repeating of a question that is not being answered by anyone. Such repetitions appear on everyone's screens and tend to annoy all participants.

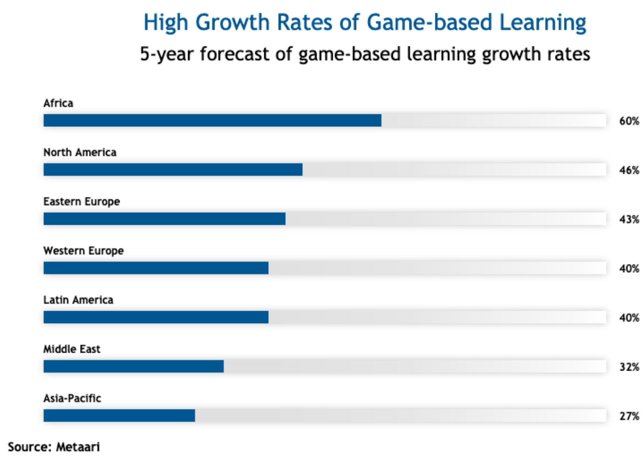
The next step is to have threaded discussions, where a single lecture may be followed by multiple threaded topics. In such a scenario, each participant may be actively involved in three, five, or any other number of discussions threads, all while listening to the lecturer. While such a practice may be difficult to grasp for some, many of today's students see it as the only way to keep their attention throughout the lecture.

Formulating Emotional States in Explicit Manner

Virtual worlds and video games do not offer the same flexibility in terms of communication, as the face-to-face communication does. Most notably there is a lack of ability to read the other person's body language, as well as no opportunity to hear the tone of someone's voice. So there are virtual chats, but virtual chats rely heavily on typing, and as such must use alternative ways to insure that the message that is being communicated is being perceived correctly. To that end, participants in virtual and gaming environments have adopted and learned how to make their emotional states explicit. They do so not just through their choice of avatars, but also by utilizing a complex vocabulary of expressions that reflect their mood. The examples of such expressions would be “Great point you made *smiles*” or “Lets get together later *waves*”. This can motivate the learners, but also the teachers and move them towards the decision to use video games specifically designed for the process of education in their regular teaching work, not being afraid that usage of video games or virtual environments in the educational process would affect learners’ or teacher’s ability to express their thoughts and emotions.

Conclusion: Gamification as Future Addition to the Educational Process

The influences of new media and new technologies onto teaching and learning processes, together with the effects they might produce are still a topic to be discussed, and a field to be practically explored. Internet, gaming and virtual environments are developing swiftly, and the possibilities that their platforms enable and offer are yet to be discovered. With the creation of new perspectives within the field of gamification, we can think about the new strategies applicable to educational processes. Their main focus should still be oriented towards teaching/learning motivation, creativity, interpersonal communication and better application of knowledge of both teachers and students. This brings us to the key words of today’s educational process merged with technology: communication and cooperation. Communication doesn’t relate only to traditional teacher-student dynamics, but is also heavily relying on technology development. One of the most interesting questions would certainly be the way technology opens up new possibilities of communication, education and presence. Contemporary process of education is inseparable from technology, and technological knowledge that young generations possess (especially Millenials and post-Milennials) might be an ideal ground for introducing gamification strategies into an educational process. All of this, for sure, doesn’t ignore following questions that would also include the issues of digital literacy of the generations of teachers, the traditional norms of academic contexts in different parts of the world, as well as the issue of Internet/digital tools (un)availability.



However, educational processes are nevertheless continually developing, bringing more and more necessity to open up the question of gamification, virtual worlds and distance learning strategies in the times of technoconnection. Learning processes will surely change, possibly bringing more interactivity, game-like structures and cooperation of all the acters in the field. Highly interactive environments, as gaming/virtual/digital worlds are definitely showing a huge potential and effectivity; but in order for them to be systematically applied in the schooling system, we need to work on the motivation of those who would use it continually. This refers both to teachers, as well as to students and other active agents that might be important for the process: educational institutions, programmers, and digital market developers. The possibilities that asynchronous gaming interactive learning brings also could intrigue educational institutions and motivate them to create study programs open for more students (for example, distance learning students in different time zones, or regularly employed students that find it difficult to adapt their working hours with their classes), or for their specific interests.

All these issues, just lightly touched by this text, are opened up as an incentive to think further about the possibility of using video games and virtual environments in future educational projects and practices. Gamification of education would certainly count into one of those contributions of the future times that we, both as educators and continual learners, would love to see in the years to come.

References

Aldrich, C. (2009). *Learning Online with Games, Simulations, and Virtual Worlds*. San Francisco: Jossey-Bass/Pfeiffer.

Aldrich, C. (2009). *The Complete guide to simulations and serious games*. San Francisco: Jossey-Bass/Pfeiffer.

Barrie, E. 2001. *Meaningful interpretative experiences from the participants perspective.* PhD diss., Indiana University.

Biro, G. I. (2014). Didactics 2.0: a pedagogical analysis of gamification theory from a comparative perspective with special view to the components of learning. *Procedia - Social and Behavioral Sciences, 141*, 148–151.

Clark, R. E. (1983). Reconsidering research on learning from media. *Review of Educational Research, 53*(4)

Clark, R. (1994). Media will never influence learning. *Educational Technology Research and Development*, *42*(2), 21-29.

Dichev, C., & Dicheva, D. (2017). Gamifying education: what is known, what is believed and what remains uncertain: a critical review. *International Journal of Educational Technology in Higher Education, 14*(1), 9. https://doi. org/10.1186/s41239-017-0042-5.

DomíNguez, A., Saenz-De-Navarrete, J., De-Marcos, L., FernáNdez-Sanz, L., PagéS, C., & MartíNez-HerráIz, J. J. (2013). Gamifying learning experiences: Practical implications and outcomes. *Computers & education, 63*, 380-392.

Finn, J. D. (1964). The Franks had the right idea. *NEA Journal, 53*(4), 24-27.

Gee, J. P. (2003). *What video games have to teach us about learning and literacy*. (pp. 20-20). NY: Pagrave Macmillan.

Holberg B. (1985) *The Feasibility of a theory of teaching for distance education and proposed theory.*(ZIFF Papier). Hagen, Westgermany: Fern Universitat, Zentrales Institute furFernstudienforschungArbeitsbereich. (ERIC Document Reproduction Service No. ED290013)

Holberg, B. (1986) *Growth and structure of distance education* (3rd ed.). London: Croom Helm.

Holberg, B. (1995) *The sphere of distance education revisited.* (ERIC Document Reproduction Service No. ED386578)

Keegan D. (1988) *Theories of distance education: Introduction.* In D. Stewart, D. Keegan & B. Holmberg (Eds.), *Distance education: International Perspective* (pp. 63-67). New York: Routledge.

Keegan D. (1995). *Distance education technology for the new millennium: Compressed video teaching*. (ERIC Document Reproduction Service No. ED389931).

Keegan, D. (1996) *The foundations of distance education* (3rd. ed). London: Croom Helm.

Keith, N., and M. Frese. (2008). Effectivness of error management training: A meta-analysis. *Journal of Applied Psychology 93*, 59-69.

Klein, T.A., T.Endrass, N. Kathmann, J. Neumann, D.Y. von Cramon, and M. Ullsperger. (2007). Neural correlates of error awareness. *Neuroimage 34*(4), 1774-1781.

Ledoux, J. (1998). *The emotional brain*. New York: Simon & Schuster.

Moore, M. (1994) Autonomy and interdependence.The American Journal of Distance Education, 8(2), 1-5.

Squire, K., Barnett, M., Grant, J. M., & Higginbotham, T. (2004). Electromagnetism supercharged! Learning physics with digital simulation games. *Proceedings of the 2004 International Conference of the Learning Sciences*. Los Angeles: UCLA Press.

Wedemeyer, C. (1981). *Learning at the backdoor. Madison.* WI: University of Wisconsin Press

Innovative Technologies in Science Education and New Approaches in Technology

Munise Seckin Kapucu
University of Eskisehir Osmangazi
Hanne Turk
University of Eskisehir Osmangazi

Introduction

Technology is seen as an indispensable part of our life in this period which we call digital age. In addition, new generation students, who are called digital natives in many national and international reports, are expected to be information technology literate during their educational life and for job opportunities in future life, and this is considered to be an important quality for them (Hills et al., 2016). Accordingly, knowing and using the technology is thought to be important.

During this era, technology is seen as a discipline that people designed by using science (Simon, 1983). Technology is also considered as a tool that can be used in different areas and play an important role in facilitating the work of individuals (Saettler, 1968). In addition to this, the integration of technology, which can be used in almost every area, into the education also comes to the agenda and in this regard, efforts are made in the educational policies of the countries. Within the scope of these efforts, the technologies used in education from past to present are discussed, they are updated with innovative technologies and included in the education process. Accordingly, contemporary and innovative technologies can be included in the curriculum and students are offered the opportunity to be intertwined with technology. Meanwhile, with the inclusion of technology in all areas of our lives, new and effective approaches are preferred in education. Adopting innovative and effective approaches for learning and teaching processes of the new generation, which is born into and growing in the digital age, is of great importance for the efficiency of education. Therefore, today's teachers are recommended to use innovative technologies in their classes in order to provide a better and effective education to new generation/digital individuals. In this sense, technology is used as a teaching tool and can play an auxiliary role in teaching, especially in areas like science where technology is considered to adapt easily (Commission on Instructional Technology, 1970).

In science education, various technologies have been used from past to present, including computer, projection, simulation, web 2.0 tools, 3-D printers, virtual laboratories and recently augmented reality, virtual reality, and digital hologram. These technologies are integrated into education programs as teaching tools in order to increase the efficiency of the education. At the same time, the individuals who have the grasp of the technology are trained to meet the needs of the technology age. Especially the augmented reality, virtual reality and digital hologram technologies, which are frequently mentioned recently and have been used in different areas before, are considered important in terms of the up-to-dateness of education and it is considered to be the key part of education-technology integration. Considering the advantages that augmented reality, virtual reality and digital hologram technologies, which are called innovative technologies today, bring to the education process, these technologies should be included in education and accordingly the desired efficiency is expected to be obtained from education. In this context, innovative technologies can provide the users with the opportunity to make 3-D observations and materializing abstract concepts through 3-D images, which can provide a great advantage to students and teachers, especially in subjects that are difficult to understand in science education. In addition, innovative technologies have several advantages such as enriching learning environments, contributing to students' imagination, saving time in the education and training process, being a simple and cheap source that every student can reach, increasing motivation for learning, thus they are expected to be compatible with education-technology integration (Chen & Wang, 2015; Huang, Chen & Chou, 2016; Squire & Jan, 2007). Therefore, technology is thought to be related to education and in this sense, education is seen as an area where technology can be used comfortably. At the same time, considering the advantages of technology-education integration in the long term, it may help in achieving the qualities such as contributing to the country's economy, preparing the ground for industrial development and having the potential of a developed countries.

"Digital Immigrants" and 21st Century Students

According to Prensky (2001), those born before 1980 are considered as digital immigrants, and those born after 1980 are considered as digital natives. Digital natives are individuals who are born into technology and who are growing up in an environment dominated by technology. Recent studies show that this generation, called digital natives, can use information technologies at a much better level than their parents and teachers (Fritsch, 2010). Teachers of digital natives are digital immigrants. Depending on the period, problems are observed between teachers (digital immigrants) and learners (digital natives) in terms of competencies in using information communication technologies (Cukurbasi & Isman, 2014; Ransdell, Kent, Gaillard-Keney & Long 2011, Waycott, Bennett & Kennedy, 2010). In this context, digital classrooms come into play and they can meet the mentioned digital individuals at the same point. The digital classroom is a learning environment equipped with technology infrastructure (Roberts, 2007). Teachers have an important role in the transformation of classrooms into digital classrooms and bringing new technologies into the classroom settings. At the same time, the teachers who will be in contact with 21st century students are expected to have sufficient technological knowledge at least as much as students. In this context, the definitions such as net generation, millennium generation, digital natives, multitasking generation, digital generation, and internet generation support this fact (Corlett, Sharples, Bull & Chan, 2005).

In parallel with the rapid developments in technology, the search for learning environments that will give 21st century learner skills continues at full speed. The new technologies are expected to improve teaching-learning processes (Corlett, Sharples, Bull & Chan, 2005).

ISTE Standards for Teachers

In 2008, the International Society for Technology in Education-(ISTE) published a series of forward-looking standards for teachers to support students' learning and creative thinking, design digital age activities and assessments, model digital studies, promote digital citizenship, modelling and engage in professional growth and leadership (Trust, 2018). ISTE standards for teachers are the standards describing technology use competencies of teachers. These standards include sub-categories such as learner, leader, citizen, collaborator, designer, facilitator, and analyst. The mentioned standards are expected to encourage collaboration with peers, deepen the practices, and guide students in their own learning by rethinking traditional approaches (ISTE, 2020). In addition, these standards cover the areas of competence such as the design of learning environments suitable for digital age, the work in digital age and being a model for learning (Trust, 2018). Institutions used ISTE standards to initiate the reform of the teacher education programs (Bucci, Cherup, Cunningham & Petrosino, 2003). Later, the use of these standards became widespread (Wiebe & Taylor, 1997).

Eight key competence area has been specified within Turkish Qualifications Framework (TQF), namely "communication in the mother tongue, communication in foreign languages, mathematical competence and core competences in science/technology, digital competence, learning to learn, social and civic competences, sense of initiative and entrepreneurship, cultural awareness and expression" (MoNE, 2018). The review of these skills reveals the emphasis put on science and technology skills. Especially mathematical competence, core competences in science/technology and digital competence cover the use of information and communication technologies in daily life. On the other hand, 21st century skills, are considered under three categories and they include learning and innovation skills, life and career awareness, and information media and technology skills. Information, media and technology skills are also prominent in 21st century skills (Partnership for 21st Century Skills, 2013). The skill of using information and communication technologies effectively is reported as one of the basic skills of 21st century skills (Voogt & Roblin, 2010).

Individuals who have information literacy, media literacy and information communication technology literacy skills are assumed to be able to acquire 21st century technology skills. In this sense, the concept of literacy should be perceived as individuals having the ability to live by working in a technological world and being able to acquire technology-based skills (Panel, 2002). NCREL (2003) has defined 21st century skills that must be acquired by the next generation to overcome the challenges of globalization arising from the advancement of knowledge and technology. There are four main areas mentioned in 21st century skills: digital age literacy, creative thinking, effective communication and high efficiency. The digital age literacy skills that comply with NCREL (2003) are basic literacy, scientific literacy, economic literacy, technological literacy, visual literacy, information literacy and multicultural literacy (Kamisah & Neelavany, 2010).

Science Education and Educational Technologies from Past to Present

Science education is one of the areas that can easily adapt to technology and the reflections of technology are frequently encountered in science education. The reason for this harmony between technology and science education is; the students consider science course as a course difficult to understand, abstract concepts are quite common in science education, and biology-based topics such as cells, systems and organs, DNA and genetic code require 3-D examinations. Accordingly, in order to eliminate the mentioned reasons or to reduce their effects, different technological equipment is employed in science classes, trying to break students' prejudices about the science course. At the same time, various technologies can be used to make science education enjoyable and to increase motivation towards the course.

Technologies used in science education varied from past to present, depending on the development of technology. Computers, which we saw in classroom settings years ago, which was forming one of the first steps of education-technology integration, are considered quite ordinary today. In the following years, considering the advantage of computers in education, the projectors took their place in the classroom settings. These were followed by various technologies such as simulations, 3-D printers, web 2.0 tools, industry 4.0 tools, and virtual laboratories that are used in the field of education. Today, the efforts are made to ensure that these technologies are updated and placed in classroom settings, and at the same time, it is aimed to bring a different perspective to education by utilizing 21st century technologies. In this context, 21st century technologies are called as innovative technologies and several studies are carried out to bring them into classroom settings. Innovative technologies such as augmented reality, virtual reality, and digital hologram are employed in the 21st century, especially in the teaching of subjects and concepts included in science education. In our country, the emphasis put on digitalization and technological competencies in the recent science curriculum also supports the infrastructure of the use of innovative technologies in the classroom setting.

Digital competence and technological competence sub-dimensions, which are included within the framework of the basic competences of the science curriculum updated in 2018, also emphasize students' technological knowledge and skills and set the training of technology using individuals as an objective. In this context, the education system can change according to the development of technology and technology-education integration can be provided on education policies as well.

Innovative Technologies in 21st Century Science Education

With the 21st century, the concept of innovative technologies has emerged, and the newest products of technology were put under this concept. Augmented reality, virtual reality and digital holograms are the innovative technologies that are frequently mentioned in our age. These technologies, which have been previously used in many different sectors such as art, architecture, tourism, health, attract attention with their integration into education. They can be used in science education especially for the topics that are difficult to understand, and that require 3-D examination.

A study, which examined the updated current science curriculum in Turkey in terms of innovative technologies, has reported that the following units are suitable for the use of innovative technological applications; 5th grade - Sun, Earth and Moon, the world of livings, humans and environment; 6th grade - Solar system and eclipses, matter and heat, the systems in our body and health; 7th grade - Solar System and beyond, cell and divisions; and 8th grade- DNA and genetic code, pressure (Seckin-Kapucu, 2020).

Augmented Reality

Augmented reality, which is one of the innovative technologies, is considered as the technology that can create a realistic simulation and experimental environment for its users and offer the opportunity to make observation in this environment (Azuma, 1997). At the same time, augmented reality technology is seen as the enrichment of the environment by imaging the real world with cameras or wearable technologies. Thanks to this technology, users can experience the feeling of real-like environment and take part in this environment (Azuma, 1997; Milgram & Kishino, 1994).

Azuma (1997) emphasizes three features of augmented reality; combining reality and virtuality, enabling simultaneous interaction and containing 3-D objects. Milgram and Kishino (1994) describe the transition between reality and virtual environment in the diagram called "Reality-Virtuality Continuum" (Figure 1).

Figure 1. Reality Virtuality Continuum (Milgram & Kishino, 1994)

The development of augmented reality applications takes place in four steps: determining the marker, pretreatment, triggering the application and running the application (Abdusselam, 2016). At the same time, the use of augmented reality applications in and out of the classroom became very common in recent years. Enriched books used by students can be shown as the first example of augmented reality applications in schools (Abdusselam, 2016). Moreover, there are many augmented reality applications that can be used in mobile and desktop technological devices, that students can access easily and free of charge. Of these, LearnAR, ZooBurst, BuildAR are desktop applications while Aurasma, Anatomy 4D, Spacecraft3D, Quiver - 3D ColoringApp, Zoo-AR, Fetch! LunchRush, Fectar are mobile applications (Perez-Lopez & Contero, 2013). Images of some of the augmented reality applications that can be accessed easily and free of charge (Figure 2-3) are shown below.

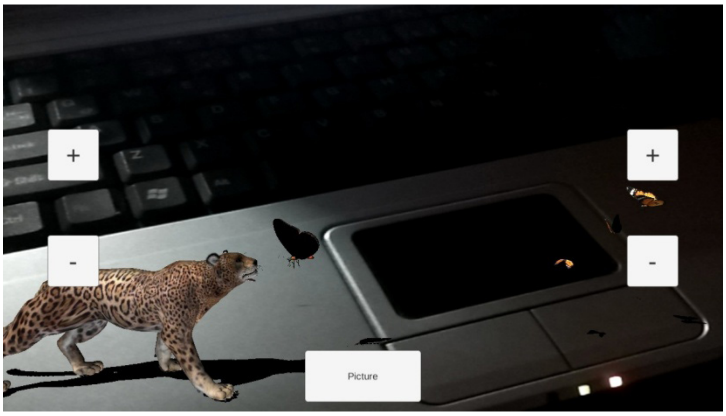


Figure 2. Zoo-AR Application
(Android Link: https://play.google.com/store/apps/details?id=com.wellinic.arshow)

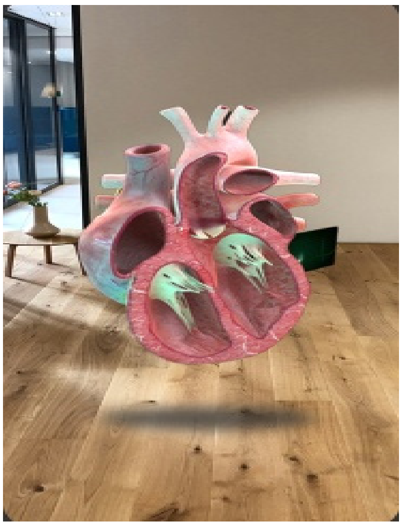


Figure 3. Fectar Application
(Android Link: https://play.google.com/store/apps/details?id=io.spoton.viewer)

Virtual Reality

Virtual reality is another innovative technology that is similar to augmented reality.

Virtual reality can be defined as a completely virtual and digital setting, created by using computer hardware or software to give the feeling of a real-like environment to the users and to provide the image of the relevant setting (Kipper & Rampolla, 2013). At the same time, virtual reality applications are thought to make scientific knowledge existing in nature more understandable (Yair, 2001). Therefore, virtual reality technology is considered to be compatible with education integration and it will contribute to the education-training process. Virtual reality applications, which can be used especially in astronomy topicas in science class, can also provide different advantages to its users. Students who do not have the opportunity to have a telescope for sky investigations can examine 3-D images on topics such as sky observations, space exploration, the solar system and planets, stars and constellations via virtual reality applications and they can observe real-like digital images of the sky objects. There are many different virtual reality applications that students and teachers can easily access. Some of these applications are; Solar systemscope is Skyview, Solar walk 2, Stellarium, NASA, Google SkyMap, Celestia, Redshift-Astronomy, Earth viewer, Star chart, ISS detector, Sky Guide AR, Sky Safari 6, Star walk 2. These applications can be accessed free of charge from mobile devices stores. Some examples of virtual reality mobile applications are shown below (Figure 4-5).

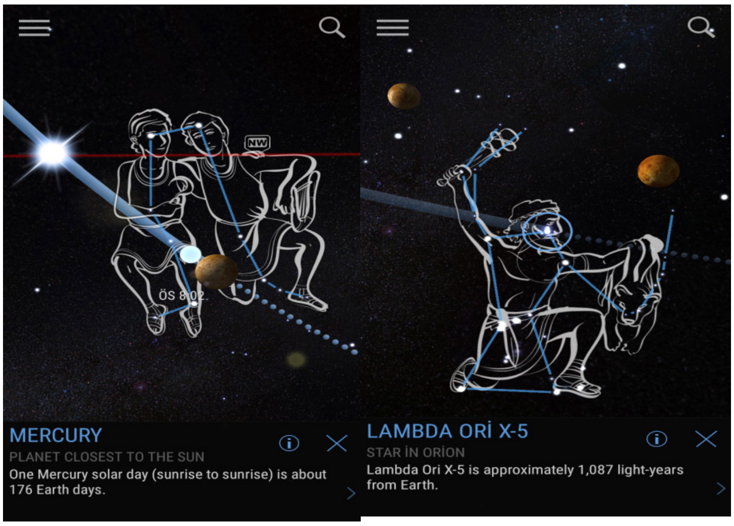


Figure 4. SkyView Application
(Android Link: https://play.google.com/store/apps/details?id=com.t11.skyviewfree)

Figure 5. Solar System Scope Application
(Android Link: https://play.google.com/store/apps/details?id=air.com.eu.inove.sss2)

Digital Hologram

Hologram is defined as a tool that can transfer 3-D images of the selected objects to different locations and ensure the continuity of the images even in the absence of these objects (Katsioloudis & Jones, 2018). In this way, thanks to the holograms, 3-D images of the objects that are not present in the setting and that are subject to examination can be accessed. Holograms that were used in areas such as architecture, tourism and entertainment, medicine, industry have recently been started to be used in the field of education as well (Rahim, Abdullasim, Saifudin & Omar, 2018; Turk, 2020). It is especially used in the teaching of subjects and concepts that are difficult to understand in science education and is also preferred as a teaching tool in the materialization of abstract concepts and subjects. Digital holograms can be prepared as videos in programs such as Powerpoint or Camtasia and images can be created with hologram pyramids (Turk, Turk & Seckin-Kapucu, 2020). In science education the use of hologram is preferred in the topics requiring a microscope to observe, such as cells, genes and chromosomes. The image of chromosome described in the DNA and genetic code unit of science education is shown below.

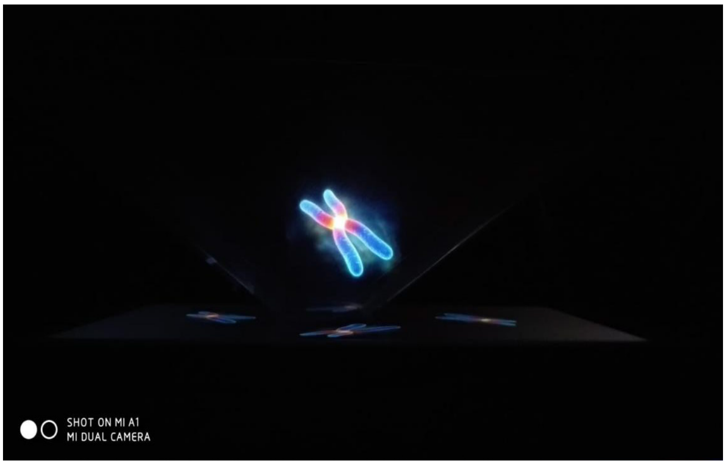


Figure 5. Hologram Image of a Chromosome (Turk, 2020).

Advantages of Innovative Technologies to Education

The introduction of innovative technologies into our lives in 21st century and their integration into education as well as in different areas such as health, art, medicine, tourism and industry have brought many advantages. Accordingly, the use of innovative technologies in education enriches learning environments and helps to prepare the appropriate infrastructure for different learning activities. In addition, they are effective in saving time allocated for teaching and learning and they can be easily used as textbooks as they can be moved easily into the classroom settings (Cakıroglu, Gokoglu & Cebi, 2015; Kol, 2012).

The use of augmented reality and virtual reality, which are among 21st century technologies, in education, especially in science education, draws attention with the advantages it provides to students and teachers. With the 3-D images created by these technologies, abstract concepts can be materialized and student prejudices for difficult-to-understand topics can be broken. At the same time, as these technologies appeal to more than one sensory organ, different types of intelligence existing in students can be revealed and the efficiency of the education can increase. In addition, augmented and virtual reality technologies that provide the opportunity to have fun in the lessons, are the technologies that provide easy access for the teachers. This fact also provides an advantage to bring virtual reality technologies into the classroom setting easily (Chang, Hou, Pan, Sung & Chang, 2015; Huang, Chen & Chou, 2016; Lin, Duh, Li, Wang & Tsai, 2013). .

Digital holograms, which are frequently mentioned today, and we see the examples in education, still remains up to date in the education world with the advantages they provide. Digital holograms provide the opportunity to create the images of objects that are not present in the setting, allow to examine them in the absence of the tools such as microscopes or telescopes, and give the opportunity to observe 3-D images of the objects, such as extinct creatures, which are considered as significant advantages (Kalansooriya, Marasinghe & Bandara, 2015). Also, the advantages of digital holograms in the long term are; contributing to the country's economy and industry, strengthening the country's economy by creating a technology market and technology industry, allowing the development of the industrial infrastructure with innovative technologies in education, and creating a different perspective to education through innovative teaching methods and techniques (Mavrikios et al., 2019).

Literature Review

The scanning of the web of science database for "innovative technology" keyword showed that the studies under this title are mostly in America, China, Spain, Russia and England. These studies were found to be written in English, Spanish, Russian, Chinese and Portuguese, respectively. The highest number of studies on this topic was conducted in 2017, followed by 2018, 2016, 2015 and 2019. There are mostly conference papers on this subject, followed by articles, book chapters, reviews, and early access studies. The author named HWANG GJ was the author with the highest number of works on this subject, followed by CHU HC, HUSANU INC. The studies on innovative technologies were observed to concentrate in areas such as education, computer science, engineering, social sciences, business economics, psychology, library science, linguistics and communication. Accordingly, the studies on the use of innovative technologies in education and especially in science education was observed to increase since the beginning of 2000s.

In their study, Chen, Chi, Hung, and Kang (2011) concluded that the use of technology in education offers students the opportunity to actively participate in the lessons, and that permanent and meaningful learning is provided. Ma, Gu and Wang (2014) showed that the use of technology in education has many advantages and emphasized that one of the advantages is practicality.

In their study, Cheung and Hew (2009) emphasized that the use of technology and the advantages it provides are the reasons of preferring technology in education. Similarly, Ryu and Parsons (2012) suggested that the reason of the use of technology in education is the advantage of increasing learning.

There are many research findings showing that AR, which is one of the innovative technologies, helps to materialize abstract concepts (Chang et al., 2015; Huang, Chen, & Chou, 2016; Lin et al., 2013; Sommerauer & Müller, 2014; Tsai et al., 2013). Chen (2006) showed that using AR, students understand chemical structures better than textbooks. In the study of Sin and Zaman (2010), students learned the characteristics of the solar system using a textbook or AR. Wojciechowski and Cellary (2013) concluded that with the use of augmented reality applications in education, learners are motivated for learning and that their learning graphics are improved. In addition, Singhal, Bagga, Goyal, and Saxena (2012) concluded that augmented reality technologies improve students' research skills and also the interaction between teacher and student is positively affected. In the study conducted by Abdusselam and Karal (2012), the augmented reality practices were found to motivate students' participation in activities, increase their interest in the lesson, and they were eagerly involved in the classes.

Regarding the studies on teaching astronomy concepts in science education, virtual reality programs were reported to be effective (Barron & Orwig, 1997; Chen, Yang, Shen, & Jeng, 2007; Diakidoy & Kendeou, 2001; Trundle & Bell, 2010).

The review of the literature on innovative technologies revealed that the studies in this area have increased especially in recent years and the use of innovative technologies in education has been discussed in terms of different aspects. Sheet et al. (2014) have examined the examples of the use of holograms, which is one of the innovative technologies, in education, and concluded that this technology should be used in education, and since it is easy to access and low cost, it may be one of the most frequently used technologies in the future. Orcos and Magrenan (2018) used hologram technology to teach cells and divisions in science education and consequently, they concluded that digital holograms should be used as a teaching tool to increase students' motivation and students' satisfaction level towards the hologram is high.

In their study, Yamaguchi and Yoshikawa (2012) revealed that holograms are effective in students' concrete learning. As a result of the School and Unver's (2016) research that aimed to support teacher candidates' thinking and problem-solving skills through holograms, teacher candidates' astronomy knowledge was found to be increased with the products they created in the field of astronomy.

In their literature review about the use of technology and hologram technology in education, Ramachandiran, Chong and Subramanian (2019) concluded that educational technologies have a significant role in increasing learning curves of 21st century learners.

Conclusion

Of late years, lifelong learning individuals are needed. These individuals are expected to learn how to learn in every setting and to take responsibility of their own learning. Thanks to information and communication technologies, individuals can access information in anywhere and at any time. Therefore, learning can take place not only in formal but also in informal settings, which offer individuals a variety of learning environments. Informal learning environments include houses, streets and playgrounds, other settings (museums, botanical gardens, planetariums, etc.), mobile technologies, web. 2.0 applications and e-learning areas (Turk & Seckin-Kapucu, 2020). Technologic equipment that support informal learning process include mobile technologies, web. 2.0 applications and e-learning areas. The technologies considered as 21st century technologies and called innovative technologies can take place in both formal and informal educational settings. Hence, lifelong education can be provided anywhere, and the efficiency of the education can be increased. At the same time each individual can easily access the mentioned technologies and the ease of use of these technologies contributes to learn using technology in almost every area. This fact also provides advantages for the education and training processes of the countries in the long term and the reflection of these advantages on education is of great importance for the students of today, who are the individuals of the future. In addition, technological competence, which is one of the requirements of our age, can be acquired through educational programs adopted by countries, having the required technological equipment. In this way, the individuals who will have no problems in technology in the future, who have the ability to use technology and who have a grasp of technology, are raised. This is also seen as an indicator of the development level of countries. Developed countries raise well-equipped individuals, individuals who can keep up with the advancing technology can easily benefit from the job opportunities and individuals who have technological competence are employed in almost every area because of the active use of technology, which support this idea. Therefore, technology is considered to have an important role in both formal and informal education and technology literate individuals should be trained. In this context, technology-supported projects and training programs should be conducted, hence the integration of individuals with technology should be ensured. Science education includes many topics, in which technology can be used, and it is necessary to provide an innovative perspective to this course, where students are biased, by taking the advantage of technology's ease of learning. In this way, the link between science and technology can be strengthened and innovative approaches in science and technology can be developed.

References

Abdüsselam, M. S. (2016). Artırılmış Gerçeklik Tarayıcıları(Augmented Reality Scanners). *Eğitim teknolojileri okumaları (Education technology readings) 2016,* 19-34.

Abdusselam, M. S., & Karal, H. (2012). Fizik öğretiminde artırılmış gerçeklik ortamlarının öğrenci akademik başarısı üzerine etkisi: 11. Sınıf manyetizma konusu örneği [The effect of mixed reality environments on the students' academic achievement in physics education: 11th grade magnetism topic example]. J*ournal of Research in Education and Teaching, 1*(4), 170–181.

Azuma, R. (1997). A survey of augmented reality. *Presence: Teleoperators and Virtual Environments, 6*(4), 355–385.

Barron, A. E., & Orwig, G. W. (1993). *New technologies for education*. Englewood, CO: Libraries Unlimited.

Bucci, T. T., Cherup, S., Cunningham, A., & Petrosino, A. J. (2003). ISTE standards in teacher education: A collection of practical examples. *The Teacher Educator, 39*(2), 95–114.

Cakıroğlu, U., Gokoglu, S., & Cebi, A. (2015). Öğretmenlerin teknoloji entegrasyonlarına yönelik temel göstergeler bir ölçek geliştirme çalışması [Basic indicators for teachers' technology integration: A scale development study]. *Gazi University Journal of Gazi Educational Faculty, 35*(3), 507–522.

Chang, Y. L., Hou, H. T., Pan, C. Y., Sung, Y. T., & Chang, K. E. (2015). Apply an augmented reality in a mobile guidance to increase sense of place for heritage places. Educational *Technology & Society, 18*(2), 166–178.

Chen, C. H., Yang, J. C., Shen, S., & Jeng, M. C. (2007). A desktop virtual reality earth motion system in astronomy education. *Educational Technology & Society, 10*(3), 289–304.

Chen, Y. C. (2006). A study of comparing the use of augmented reality and physical models in chemistry education. I*n Proceedings of the 2006 ACM international conference on Virtual reality continuum and its applications* (pp. 369-372).

Chen, Y. C., Chi, H. L., Hung, W. H., & Kang, S. C. (2011). Use of tangible and augmented reality models in engineering graphics courses. *Journal of Professional Issues in Engineering Education & Practice, 137*(4), 267–276.

Cheung, W., S., & Hew, K. F. (2009). A review of research methodologies used in studies on mobile handheld devices in K-12 and higher education settings. *Australasian Journal of Educational Technology, 25*(2), 153–183.

Commission on Instructional Technology. (1970). *To improve learning a report to the president and the congress of the United States.* Washington, DC: Commission on Instructional Technology.

Corlett, D., Sharples, M., Bull, S., & Chan, T. (2005). Evaluation of a mobile learning organiser for university students. *Journal of Computer Assisted Learning, 21*, 162-170.

Cukurbası, B., & Isman, A. (2014). Öğretmen adaylarının dijital yerli özelliklerinin incelenmesi (Bartın Üniversitesi örneği) [Examination of teacher candidates' digital natives features (Example of Bartın University)]. *Bartın University Journal of Faculty of Education, 3*(1), 28–54.

Diakidoy, I. A. N., & Kendeou, P. (2001). Facilitating conceptual change in astronomy: A comparison of the effectiveness of two instructional approaches. *Learning and Instruction, 11*(1), 1–20.

Fritsch, T. (2010). *Actor models and digital natives: An empiric research approach for online* (Master's thesis). GRIN Verlag, Germany

Hills, C., Ryan, S., Smith, D.R., Warren-Forward, H., Levett-Jones, T., & Lapkin, S. (2016). Occupational therapy students' technological skills: Are 'Generation Y' ready for 21st century practice?*Australian Occupational Therapy Journal, 63*, 391–398,

Huang, T. C., Chen, C. C., & Chou, Y. W. (2016). Animating eco-education: To see, feel, and discover in an augmented reality-based experiential learning environment. *Computers & Education, 96*, 72–82.

International Society for Technology in Education (ISTE). (2000). *National educational technology standards for teachers.* Eugene, OR: Aut

International Society for Technology in Education (ISTE). (2020). *ISTE standards for Educators.* Retrieved from https://www.iste.org/standards/for-educators.

Kalansooriya, P., Marasinghe, A., & Bandara, K. M. D. N. (2015). Assessing the applicability of 3D holographic technology as an enhanced technology for distance learning. *Journal of Education, 1*(16),43–57.

Kamisah O., & Neelavany, M. (2010). Setting new learning targets for the 21st century science education in Malaysia. *Procedia Social and Behavioral Science, 2,* 3737–33741

Katsioloudis, P. J., & Jones, M. V. (2018). A comparative analysis of holographic, 3D-printed, andcomputer generated models: implications for engineering technology students spatial visualization ability. *Journal of Technology Education, 29*(2), 36–53.

Kipper, G., & Rampolla, J. (2013). *Augmented reality an emerging technology guide to AR*. Waltham MA: Elsevier Inc.

Kol, S. (2012). Okul öncesi eğitimde teknolojik araç gereç kullanımına yönelik tutum ölçeği geliştirilmesi [Development of attitude scale devoted to the usage of technology in pre-school education]. *Kastamonu Education Journal, 20*(2), 543–554.

Lin, T. J., Duh, H. B. L., Li, N., Wang, H. Y., & Tsai, C. C. (2013). An investigation of learners' collaborative knowledge construction performances and behavior patterns in an augmented reality simulation system. *Computers & Education, 68*, 314-321.

Ma, L., Gu, L., & Wang, J. (2014). Research and development of mobile application for android platform. *International Journal of Multimedia and Ubiquitous Engineering, 9*(4), 187–198.

Mavrikios, D., Alexopoulos, K., Georgoulias, K., Makris, S., Michalos, G., & Chryssolouris, G. (2019). Using holograms for visualizing and interacting with educational content in a teaching factory. *Procedia Manufacturing, 31*, 404–410.

MEB, (2018). *Fen Bilimleri Dersi Öğretim Programı* (İlkokul ve Ortaokul 3, 4, 5, 6, 7 ve 8. Sınıflar). [Science Education Curriculum], Ankara: MEB.

Milgram, P., & Kishino, F. (1994). A taxonomy of mixed reality visual displays. *IEICE TRANSACTIONS on Information and Systems, 77*(12), 1321–1329.

North Central Regional Educational Laboratory and the Metiri Group . (2003). *Engauge 21st century skills: literacy in thedigital age.* North Central Regional Educational Laboratory and the Metiri Group. Retrieved from http://www.grrec.ky.gov/SLC_grant/engauge21st_Century_Skills.pdf.

Okulu, H. Z., & Unver, A. O. (2016). Bring cosmos into the classroom: 3d hologram. Shelley, M., Kiray, A., & Celik, I. (Ed), *Education Research Highlights in Mathematics, Science and Technology* (pp. 81–86). ISRES Publishing.

Orcos, L., & Magrenan, A. A. (2018). The hologram as a teaching medium for the acquisition of STEM contents. *International Journal of Learning Technology, 13*(2), 163–177.

Panel, I. L. (2002). Digital transformation: A framework for ICT literacy. *Educational Testing Service*, 1-53.

Partnership for 21st Century Skills, (P21). (2013). *Framework for 21st centuryl earning*. Retrieved from http://www.p21.org/about-us/p21-framework.

Perez-Lopez, D., & Contero, M. (2013). Delivering educational multimedia contents through an augmented reality application: A case study on its impact on knowledge acquisition and retention. *Turkish Online Journal of Educational Technology, 12*(4), 19-28.

Prensky, M. (2001). Digital natives, digital immigrants part 1. *On the Horizon, 9*(5), 1–6.

Rahim, S. S., Abdullasim, N., Saifudin, S. N., & Omar, R.N. (2018). Development of interactive ophthalmology hologram. *International Journal of Advanced Computer Science and Applications, 9*(11), 451-547.

Ramachandiran, C. R., Chong, M. M., & Subramanian, P. (2019). 3D hologram in futuristic classroom a review. *Periodicals of Engineering and Natural Sciences, 7*(2), 580–586.

Ransdell, S., Kent, B., Gaillard-Keney, S., & Long, J. (2011). Digital immigrants fare better than digital natives due to social reliance. *British Journal of Educational Technology, 42*(6), 931–938.

Roberts, M. C. (2007). *The Critical Success Factors İnvolved in The İmplementation of a Digital Classroom in New Zealand* (Unpublished master's thesis). Unitec New Zealand, New Zealand.

Ryu, H., & Parsons, D. (2012). Risky business or sharing the load? – Social flow in collaborative mobile learning. *Computers & Education, 58*(2), 707–720.

Saettler, P. (1968). *A history of instructional technology*. New York: MacGraw-Hill.

Sanders, W. L., & Rivers, J. C. (1996). Cumulative and residual effects of teachers on future student academic achievement. Research Progress Report. Knoxville: University of Tennessee Value-Added Research and Assessment Center.

Schauffler, G., & Greer, R. D. (2006). The effects of intensivetact in struction on audience-accuratet acts and conversational units. *Journal of Early and Intensive Behavior Intervention, 3*,121–132.

Seckin Kapucu, M. (2020). Fen bilimleri dersi öğretim programlarının yenilikçi teknolojiler açısından incelenmesi [Examination of science curriculum in terms of innovative technologies]. M. Seckin Kapucu (Ed), *In Fen eğitiminde zenginleştirilmiş materyal üretiminde yenilikçi yaklaşımlar [Innovative approaches in enriched material production in science education]* (pp.31-45). Ankara: Pegem Akademi.

Seckin Kapucu, M., & Turk, H. (2020). Zenginleştirilmiş materyaller ve geleceğin sınıf ortamları [Enriched materials and future classroom environments]. M. Seçkin Kapucu (Ed), *In Fen eğitiminde zenginleştirilmiş materyal üretiminde yenilikçi yaklaşımlar[Innovative approaches in enriched material production in science education]* (pp.195–205). Ankara: Pegem Akademi.

Sheet, A., El Sayed, M., Maged, M., Mona, I., Mariam, A., Solouma, N. H., & Abdel-Mottleb, T. (2014). 3D computer generated medical holograms using spatial light modulators. *Journal of Electrical Systems and Information Technology, 1*(2), 103–108.

Simon, Y. R. (1983). *Philosophy and technology.* New York: Free press.

Sin, A. K, & Zaman, H. B. (2010) *Live solar system (LSS): Evaluation of an augmented reality book-based educational tool*. International symposium in information technology, Malaysia, June 2010.

Singhal, S., Bagga, S., Goyal, P., & Saxena, V. (2012). Augmented chemistry: Interactive education system. *International Journal of Computer Applications, 49*(15), 1–5.

Sommerauer, P., & Müller, O. (2014). Augmented reality in informal learning environments: A field experiment in a mathematics exhibition. *Computers & Education, 79*, 59–68.

Squire, K. D., & Jan, M. (2007). Mad city mystery: Developing scientific argumentation skills with a place-based augmented reality game on handheld computers. *Journal of Science Education and Technology, 16*(1), 5–29.

Trundle, K. C., & Bell, R. L. (2010). The use of a computer simulation to promote conceptual change: A quasi-experimental study. *Computers & Education, 54(*4), 1078–1088.

Trust, T. (2018). 2017 ISTE Standards for educators: From teaching with technology to using technology to empower learners. *Journal of Digital Learning in Teacher Education, 34*(1), 1–3.

Tsai, M. K., Liu, P. H. E., & Yau, N. J. (2013). Using electronic maps and augmented reality based training materials as escape guidelines for nuclear accidents: An explorative case study in Taiwan. *British Journal of Educational Technology, 44*(1), 18–21.

Turk, H. (2020). Fen eğitiminde buz kırıcı etkinlikler olarak dijital hologramlar [Digital holograms as ice breaker activities in science education]. M. Seckin Kapucu (Ed), *In Fen eğitiminde zenginleştirilmiş materyal üretiminde yenilikçi yaklaşımlar [Innovative approaches in enriched material production in science education]* (pp.177–193). Ankara: Pegem Akademi.

Turk, H. (2020). *Innovative technology applications in science education: Digital holography* (Unpublished master's thesis). Eskisehir Osmangazi University, Turkey.

Turk, H., & Seckin Kapucu, M. (2020). Fen eğitiminde informal öğrenme ortamı olarak planetaryumlar [Planetariums as an informal learning environment in science education]. M. Seckin Kapucu (Ed), *In Fen eğitiminde zenginleştirilmiş materyal üretiminde yenilikçi yaklaşımlar [Innovative approaches in enriched material production in science education]* (pp.177–193). Ankara: Pegem Akademi.

Turk, S., Turk, H., & Seckin Kapucu, M. (2020). Fen eğitiminde holografik uygulamalar [Holographic applications in science education]. M. Seckin Kapucu (Ed), *In Fen eğitiminde zenginleştirilmiş materyal üretiminde yenilikçi yaklaşımlar [Innovative approaches in enriched material production in science education]* (pp.137–155). Ankara: Pegem Akademi.

Voogt, J., & Roblin, N. P. (2010). *21st century skills, discussion paper*. Netherlands: Universiteit Twente.

Waycott, J., Bennett, S., & Kennedy, G. (2010). Digital divides student and staff perceptions of information and communication technologies. *Computers & Education, 54*(4), 1202–1211.

Wiebe, J. H., & Taylor, H. G. (1997). What should teachers know about technology? A revised look at the ISTE foundations. J*ournal of Computing in Teacher Education, 13*(3), 5–9.

Wojciechowski, R., & Cellary, W. (2013). Evaluation of learners attitude toward learning in ARIES augmented reality environments. *Computers & Education, 68*, 570–585.

Yair, Y. (2001). 3D-virtual reality in science education: an implication for astronomy teaching. *Journal of Computers in Mathematics and Science Teaching, 20*, 293–305.

Yamaguchi, T., & Yoshikawa, H. (2012). New education system for construction of optical holography setup tangible learning with augmented reality. *Journal of Physics, 415*(1), 1–8.

Technology for Education

Kadriye Kayacan
Necmettin Erbakan University
Fatma Tuba Ulker
Necmettin Erbakan University

In these years, when we are getting ready to leave the first quarter of the 21st century behind, the importance of the 21st century skills that developed countries aim to gain has become more noticeable. The prominent fields of study for these skills are economy and technology. Today, technological progress will undoubtedly continue to change the way we work, live, and survive in the coming decades. Since the beginning of the new millennium, the world has witnessed the emergence of social media, smartphones, self-driving cars, and autonomous flying vehicles. There have also been huge leaps in energy storage, artificial intelligence, and medical science. We are facing immense challenges in global warming and food security, among many other issues (Zohuri, 2020).

Economy and technology are two mutual concepts that improve each other and cause it to progress. At the same time, technology is of great importance for countries to survive economically and politically and to offer career options for individuals (Canbazoğlu, 2019) The developing technology has constructed a bridge between science and tools that meet the human needs.

When it comes to the needs of people, the first thing that should come to mind should be education. As technology has become an integral part of our lives today, it has become one of the requirements of education. The importance of technology for education in situations such as pandemics, earthquakes, floods, and terrorist attacks that affect the whole world, such as Covit 19, has once again been revealed. However, it is not an easy task to achieve sustainability in education in this digital era as these digitally experienced students learn differently and have new vernaculars. Their needs and pace of learning is much diversified than before. Furthermore, educators must be skilled and trained to assess these young minds using the right assessment tool that can capture the 4Cs such as creativity, communication, collaboration and critical thinking skills which is within the 21st century skills framework (Ramachandiran & Mahmud, 2018).

Today, internet usage has shifted from Web 1.0 technology, which is defined as receiving information, to Web 2.0 technologies that allow interactions such as receiving, sharing and commenting on information. Web 2.0 a term we use almost every day, is an ambiguous concept that refers both to a large and shifting set of technological tools and to an approach to the socially and technologically integrated use of technology (Light and Polin, 2010).

Technologies in education include different environments designed specifically to fulfill certain objectives in teaching and learning. The most commonly used information and communication technology resources include the internet, multiplatform applications, communication tools such as mobile messaging, email and social media, and tools for sharing files and other resources like blogs, e-portfolio, MOOCs, web conference applications, etc. (Martinez et all., 2020).

Web2.0 tools,virtual worlds, simulations, haptics and mobile technologies continue this trend of co-evolution and we are only beginning to develop an understanding of what the trajectory of this co-evolution will be. De Freitas and Conole (2010) suggest five broad technological trends that are likely to have a significant impact on education:

- A shift towards ubiquitous and networked technologies
- The emergence of context and location aware devices.
- The increasingly rich and diverse different forms of representations and stimulatory environments possible.
- A trends towards more mobile and adaptive and adaptive devices
- A technological infrastucure which is global, distributed and interoperable (Conole and Alevizou, 2010).

Considering the importance of sharing the application with others as well as getting the information in education, it is thought that the use of Web 2.0 tools will be beneficial.

Teachers need to design activities in which the communication facilitated by the Web 2.0 tools is meaningful and relates to students' learning of the content or to their own lives. But when the communication is useful for a larger or more authentic goal, the students' use of the tools promotes different student and& teacher relationships. Additionally, the way kin which these net worked tools blur older boundaries between public and private, school and home requires more reflection and research (Light and Polin, 2010).

The categorisation of Web 2.0 tools in schools(Crook et al., 2008):

- Media sharing. Creating and exchanging media with peers or wider audiences.
- Media manipulation and data/web mash ups. Using web-accessible tools to design and edit digital media files and combining data from multiple sources to create a new application, tool or service.
- Instant messaging, chat and conversational arenas. One-to-one or one-to-manyconversations between internet users.

- Online games and virtual worlds. Rule-governed games or themed environments that invite live interaction with other internet users.
- Social networking. Websites that structure social interaction between members who form subgroups of friends'.
- Blogging. An Internet-based journal ordiary in which a user can post text and digital material while others can comment.
- Social bookmarking. Users submit their bookmarked web pages to a centralsite where they can be tagged and found by other users.
- Recommender systems. Websites that aggregate and tag user preferences for items in some domain and thereby make novel recommendations.
- Wikis and collaborative editing tools. Web-based services that allow users unrestricted Access to create, edit and link pages.
- Syndication.Users can'subscribe'to RSS feed enabled websites so that they are automatically notified of any changes or updates in contentvia an aggregator (Conole and Alevizou, 2010).

Web 2.0 Tools in Education

For Prepare Effectıve and Powerfull Presantatıons

Education is an interactive progress as follows learner is always in interaction with living and nonliving presences while learning. Learning materials are maybe living and nonliving objects used by teachers and students. Like microscop, models and books presentations are the most important materials used in the lessons. Because using more sensory organs while learning is increases meaningful learning. Visuals or videos included in the presentations while lecturing with presentations will also increase the sense organs used during learning. Presentation software has centered around PowerPoint style editors for at least the last 20 years (Parks, 2012). While using PowerPoint in the classroom was considered to be cutting edge, it is now seen as the epitome of boring (Strasser, 2014). Throughout the study (Alpan, 2013) , the criticisms of the students on the inefficient use of PPPs are noteworthy. For these reasons, like other social areas, making changes has become inevitable in education materials. For example, new presentation tools can be used instead of PowerPoint presentations that have been used frequently for the last 20 years.

Google Slides

Google Slides is an online presentation app that lets you create and format presentations and work with other people. You can use this application with computer, telephone and Ipad. This is a free tool for users. You can create a presentation, edit and format a presentation, share and work with others by thıs application. For create a presentation you must follow the steps below;

Open the Slides home screen at slides.google.com.

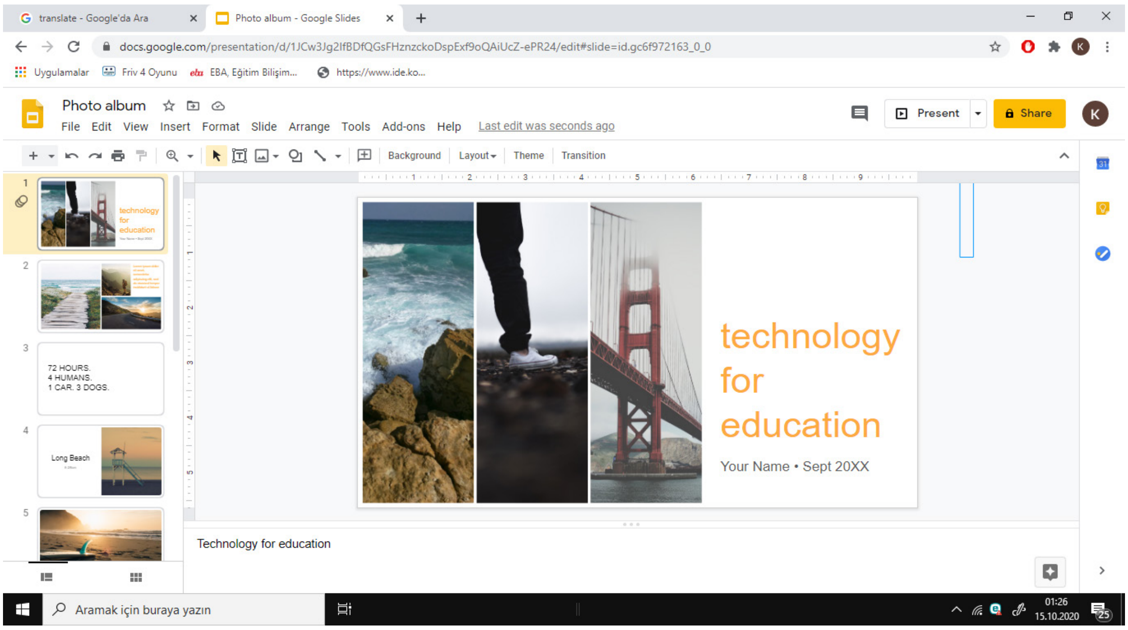
1. In the top left, under “Start a new presentation,” click New +. This will create and open your new presentation.

You can also create new presentations from the URL https://slides.google.com/create.

You can add, edit, or format text, images, or videos in a presentation with this steps.

- Insert and arrange text, shapes, and lines
- Add, delete & organize slides
- Add animations to a slide

You can share files and folders with people and choose whether they can view, edit, or comment on them.



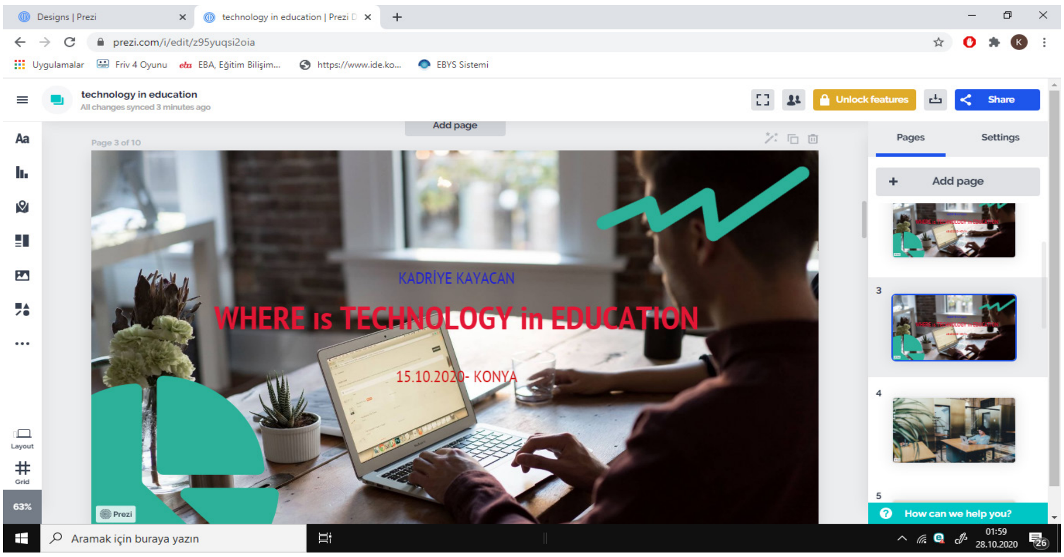
Printscreen of Googleslides

Prezi

Prezi’s one-of-a-kind open canvas lets you organize and view your presentation as a whole. “Smart builds” make it easy to organize content with a simple drag and drop method without disrupting your layout. Use the “show zoom” function to focus and reveal critical details as your story progresses. You no longer need to search through slides to find the topic you want. Freely navigate your chat presentation. You may be wondering what makes Prezi different from other presentation software like PowerPoint or Keynote. First, Prezi is completely free to use. There are upgrades you can pay to unlock additional features, but everything you need to create and share a dynamic prezi is offered for free.

Another great reason to use Prezi is that it is run entirely through your web browser, meaning there will be fewer compatibility issues than with other programs like PowerPoint. Your prezi will always look the same, no matter what computer you're viewing it on.

Because of its unique presentation style, Prezi can use movement and metaphor to help communicate a point you're trying to make. If you want your audience to really feel a sense of space and distance between locations, you could use a map template, like in the prezi below.

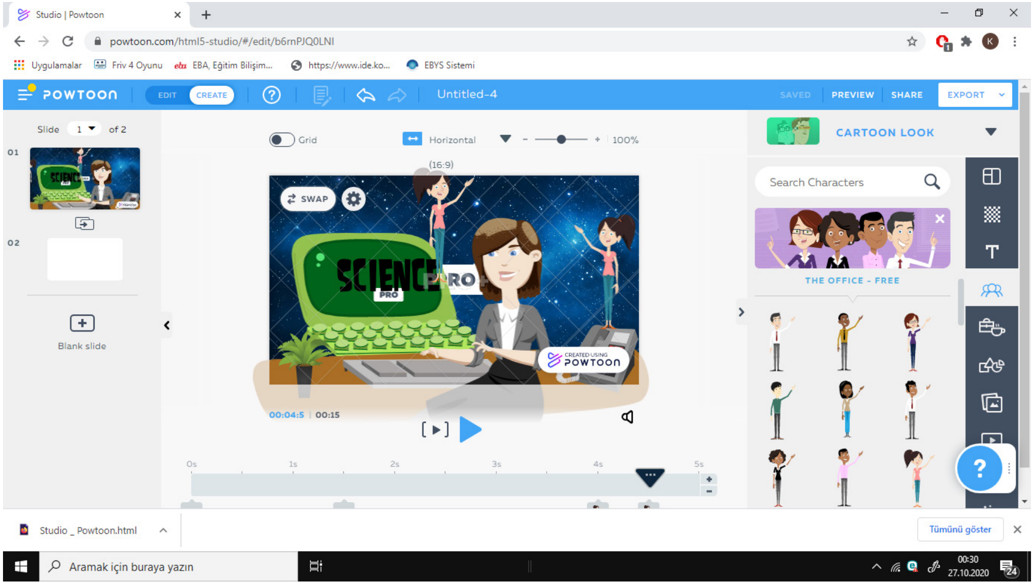


Printscreen of Prezi

Powtoon

This Web 2.0 tool is the world's leading, most user-friendly, and most intuitive animation software. Powtoon also makes education awesome. This usefull tool is designed to allow education professionals (and students) to create content that is fun to make, fun to watch - and gets your class hooked on learning.

With Powtoon, you can create engaging, animated videos with a professional look and feel. There are four different types free, pro, pro + ve agency. With free type of this tool you can create a Powtoon, upload it to YouTube, and share it with others . You can make an animation up to 3 minutes in free type of tool.



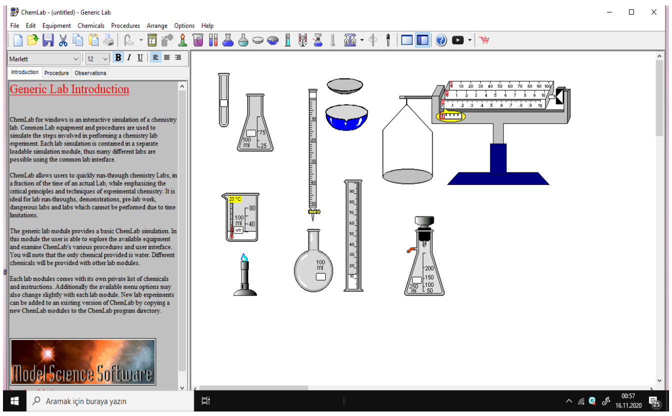
Printscreen of Powtoon

For Experiments and Applied Simulations

Chemlab

Chemlab is a kind of chemistry lab simulation that can be installed on a computer without the need for an internet connection. Therefore, experiments that are dangerous or difficult to make are performed visually in a computer environment. The application can be downloaded free of charge from https://www.modelscience.com/. When we start the application, chemistry experiment options appear such as "Acid-Base titration, Gradual crystallization, Gas compression, General laboratory, Gravimetric analysis of Chlorine, reaction kinetics in redox reactions, Heat laboratory". An explanation page opens according to the selected action. The actions to be taken afterwards are explained in order.

With this application, either an already-made experiment can be used again, or an authentic experiment can be designed. With Chemlab, students can both learn about laboratory tools and perform authentic experiments.

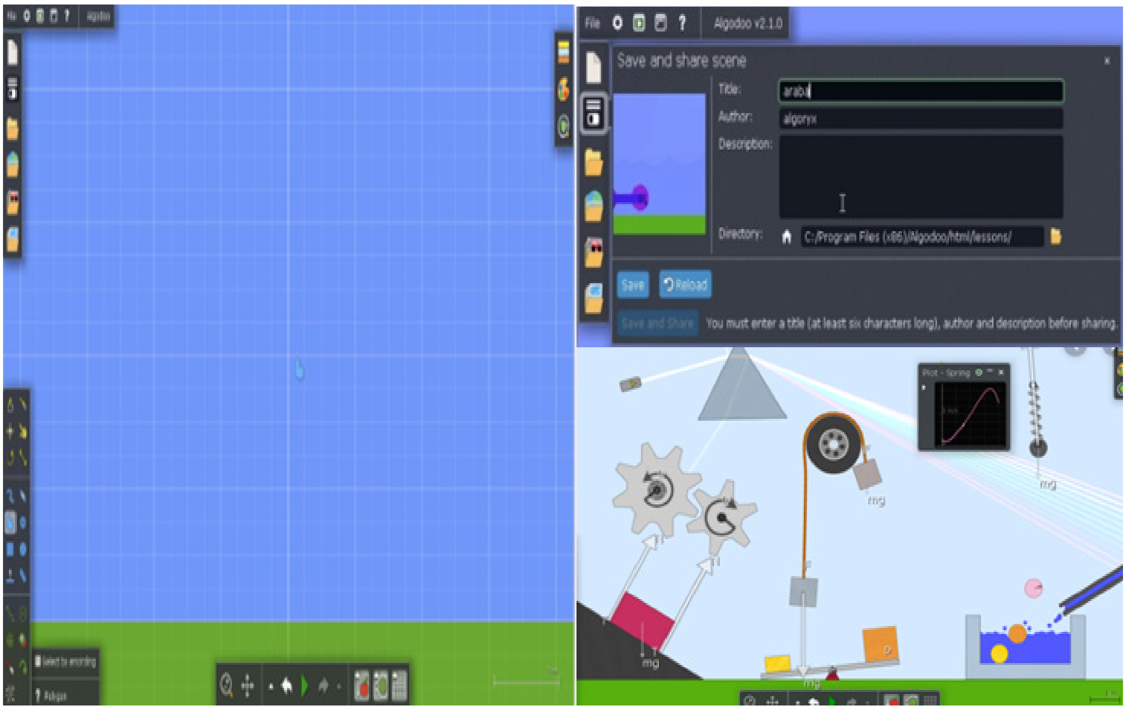


Printscreen of Chemlab.

Algodoo

Algodoo is a 2-dimensional free, educational software developed for physics subjects that can be easily simulated by drag and drop without writing code. Depending on the imagination of the teachers and students, it is used in teaching difficult to learn subjects by applying them in other disciplines within the scope of science course (such as chemistry, biology, astronomy). Algodoo's fun and motivating environment enables students to learn interactively by testing their hypotheses on science concepts, mainly physics concepts, with simulation (Hırça & Bayrak, 2013). Özer, Canbazoğlu Bilici, and Karahan (2016) reported in their study that algodoo had a positive effect on students in terms of concept learning and perceptions.

The Algodoo application can be downloaded and used free of charge on a tablet / computer. Desired designs can be prepared with the images in the lower left part of the page. With the tabs on the upper part, the readily made works can be accessed, new studies can be conducted, the studies can be saved and transferred to the USB memory when desired, and can be used on different tablets / computers. However, in order to use these on a different tablet / computer, the Algodoo application must be installed on these devices too.

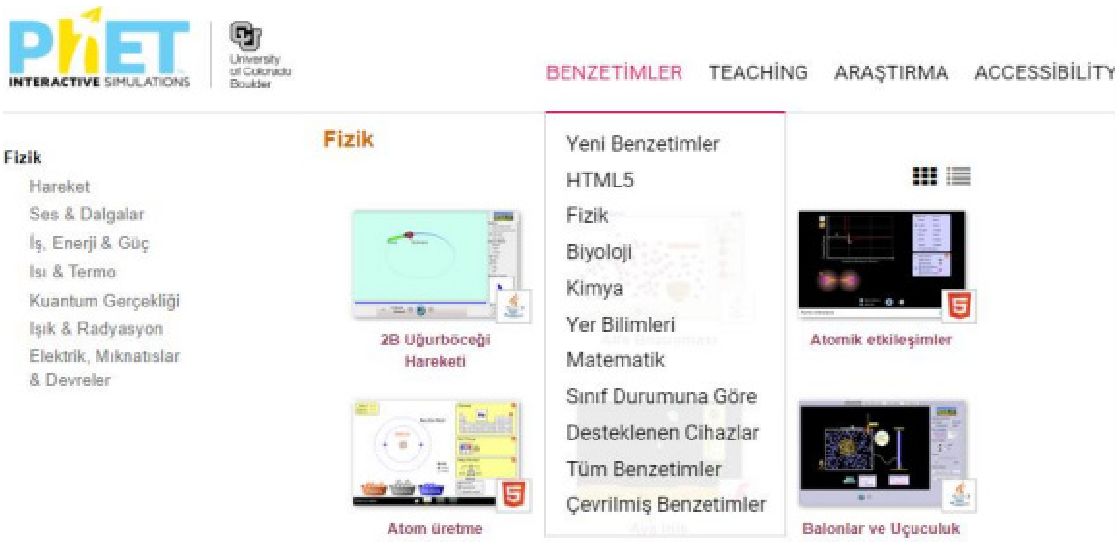


Printscreen of Algodoo.

Phet

PhET simulations design principles are based on research on how students learn (Bransford, Brown and Cocking, 2000). "PhET" is an abbreviation for "Physics Education Technology". In every simulation, the think-aloud method is utilized to receive students' ideas. A rich data source is created with these ideas for students to work. The simulations to be used can be chosen by the individual, according to the classroom situation, or levels, such as primary school, secondary school, high school and university. The teacher can share activities with the students. PhET is a free application that does not require installation. PhET simulations are not just animations, but also interactive learning environments that respond immediately with user input. In some places, students can interact with simulations by moving real objects such as batteries, bulbs, magnets, levers and switches, sliders or text boxes.

Our accessible simulations include: verbal descriptions and feedback, the use of sound and music to represent foundational science and mathematics relationships, and alternative navigation that moves beyond mouse or touch inputs. We are creating research-based, accessible STEM education resources to ensure that all students can experience the benefits of PhET Interactive Simulations (https://phet.colorado.edu/tr/accessibility).



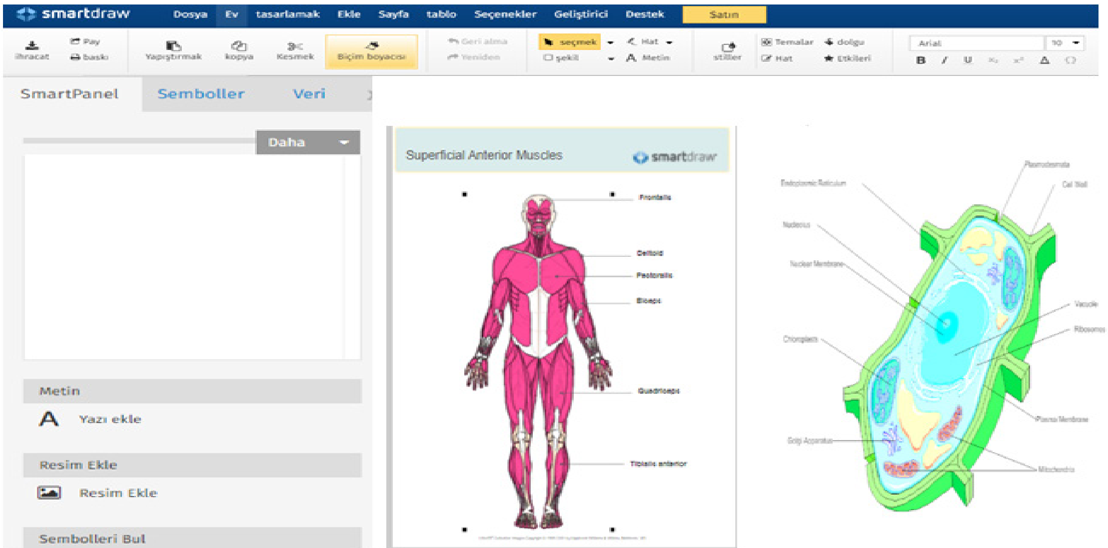
Printscreen of PhET.

For Tables, Posters, Graphics and Concept Maps

Smartdraw

Smartdraw is a software where visuals and graphics with different design features are created for various purposes, and users can use ready-made or self-designed templates (Balım, 2019). It is especially important in its use in the field of science education (Tatlı, 2017).

Smartdraw consists of three main sections. In the first section, there are twenty-four types of diagrams that can be used for different purposes. In the second section, templates for any selected diagram type are listed. In the last section, there are sample diagram images and names prepared in the type of the selected template in the second section. With the tabs at the top of the Smartdraw page, the work done can be accessed, new studies can be conducted, studies can be saved and can be printed out directly or exported and shared on different platforms (Smartdraw, 2017). The application can be used both online from a tablet or computer and by being installed on the Windows desktop. The application requires a subscription and there is a free one-week trial version available. After the trial expires, the application can be used with monthly or annual payments.

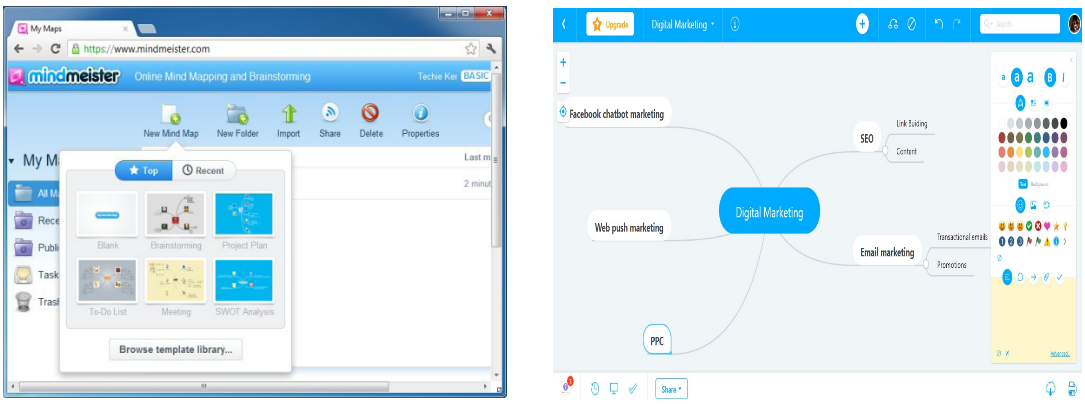


Printscreen of Smartdraw

Mindmeister

Mindmeister is a project planning platform for creating an online mind map. Students can share their mind maps with their friends and expand their mind maps by having them add or subtract from them. Changes made in shared maps are seen by other users synchronously.

The teacher can have students use mindmeister in their group projects so that they can brainstorm. Students create their mind maps by planning their projects and supporting them with personal comments such as images and links. In this way, meaningful and permanent learning about the subject can be provided for students.

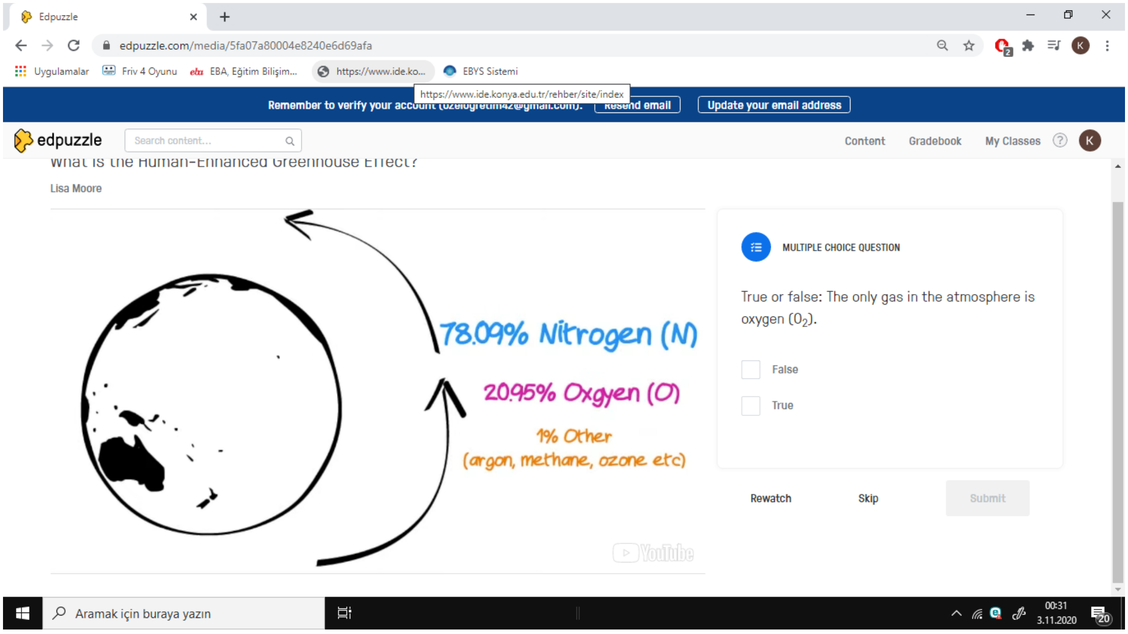


Printscreen of Mindmeister.

For Editting And Sharing Video by Creating a Classroom

Edpuzzle

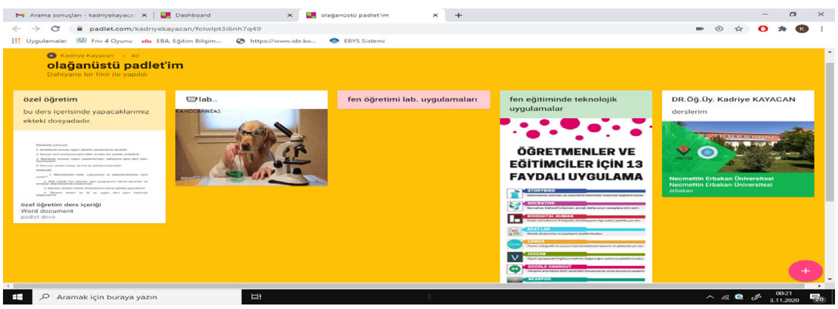
This tool is used for arranging videos from YouTube, Khan Academy, Crash Course and more. It is a useful Web 2.0 tool that can be used to share these videos in the virtual classroom created in order to add questions or audio recordings, and to edit a video about the lesson to use in the lessons. All this can be realized by creating a free membership.



Printscreen of Edpuzzle.

Padlet

Padlet is a Web 2.0 tool where users can create their own walls and share, comment and edit with other people on a certain topic. It has different versions including free and paid usage. If you subscribe to the free version, you will have the opportunity to create a padlet, share it and join another padlet. In the free version, you are allowed to create 5 padlets individually. You can add attachments such as any URL link, image, video, text, sound recording, a file from your computer, camera image in a created padlet. If you provide access in the settings, the people you share the padlet can add to your padlet, but they do not have the permission to delete or change any add-ons you add.

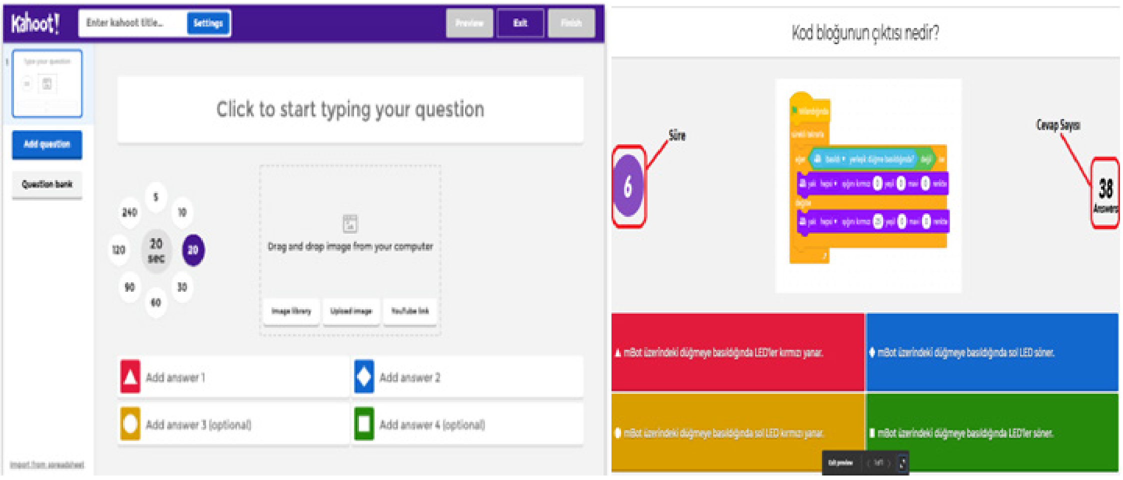


Printscreen of Padlet.

For Assessment

Kahoot

Kahoot! application, where students use only their smartphones, tablets or computers instead of cards is a free game-based learning platform that makes learning fun (Kahoot, 2017). Formative assessment can also be provided on this platform. It offers opportunities, such as creating and sharing multiple choice tests and using or editing quizzes shared by others. This application can be used directly from the phone, tablet or computer without the need for any kind of membership for the students. Here, students are scored according to the time they take to provide the correct answers to the question (Siegle, 2015; cited in Zengin, Bars, & Şimşek, 2017). If you want to create a test, you can create and use a free membership. An internet connection is required to use it. The application, which has the feature of using different question types such as multiple choice, true or false, open-ended questions while creating a test, is very interesting and fun for students.

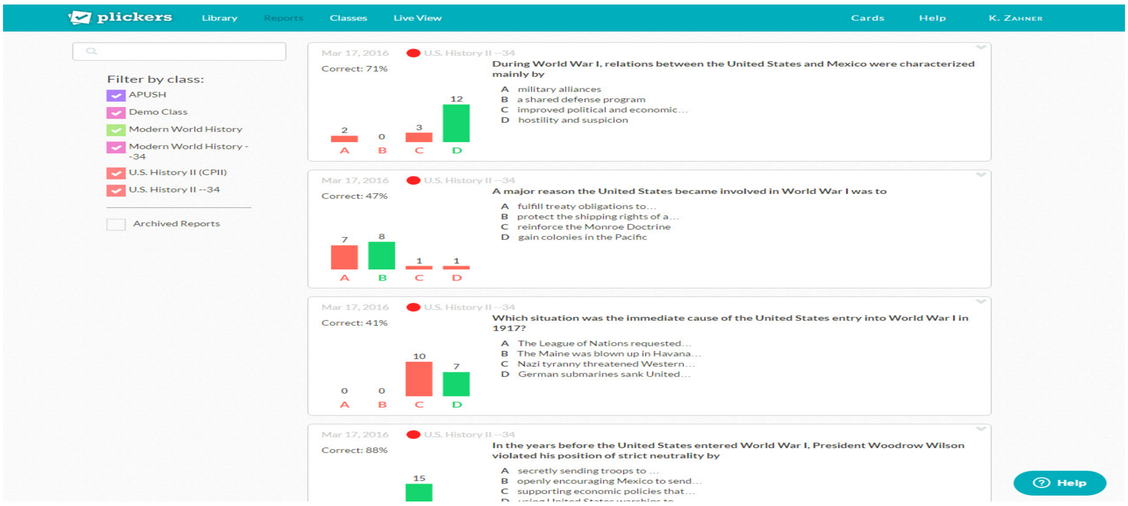


Printscreen of Kahoot.

Plickers

Plickers is a software that distributes different cards with different QR codes to students and enables the teacher to scan the cards of the students with the camera of his mobile device, transfer the instant image to the tablet, computer or smart board he uses as a graphic artist, to make formative evaluations and to give instant feedback (Howell, Tseng and Colorado-Resa, 2017; Cited in Rich, Bars and Şimşek, 2017). Plickers is an application that makes solving questions and tests fun and takes students away from stress. Classes and questions can be created on this platform. You can give tests up to 40 students at the same time in the free version of the application, which has free and paid formats.

The teacher creates a separate QR code for each student and distributes them to the students. After the questions are presented to the students, they are given some time and the students raise and place their cards so that the relevant part of the QR code is above the correct answer. The teacher scans the answers with the camera of his mobile device and transfers them to the plickers application. Plickers scans the students' answers and lists the students who gave answers. It is an application preferred by teachers for its easy use



Printscreen of Plickers.

References

ALPAN, G. B. (2013). Powerpoint ile işlenen derslere eleştirel bir bakış: Öğrenci yorumları. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi, 44*(44). Retrieved October 20, 2020 from https://dergipark.org.tr/en/pub/hunefd/issue/7792/101942.

Balım, A.G. (2019). *Fen Öğretiminde Yenilikçi Yaklaşımlar.* Ankara: Anı Yayıncılık.

Bransford, J.D., Brown, A.L. & Cocking, R.R. (2000). *How People Learn: Brain, Mind, Experience, And School.* Washington, DC: The National Academy Press.

Karahan, E. & Canbazoğlu, B.S.(2018). Stem Eğitiminde Teknoloji Entegrasyonu. A. Tekbıyık & G. Çakmakcı (Ed.) *Fen Bilimleri Öğretimi ve Stem Etkinlikleri* (s. 265-280). Ankara: Nobel Yayıncılık, ISBN:978-605-7928-31-3.

Clark, J. (2008). Powerpoint and Pedagogy: Maintaining Student Interest in University Lectures. *College Teaching, 56 (1)* ,9-44.

Conole, G. & Alevizou, P. (2010). A literature Review of the Use of Web 2.0 Tools in Higher Education. *A report commissioned by the Higher Education Academy.*

Crook, C., Cummings, J., Fisher, T., Graber, R., Harrison, C. & Lewin, C. (2008). Web 2.0 Technologies for Learning: The Current Landscape -Opportunities, Challenges and Tensions. *A Report Becta.*

Hırça, N. & Bayrak, N. (2013). Sanal Fizik Laboratuarı ile Üstün Yeteneklilerin Eğitimi: Kaldırma Kuvveti Konusu. *Genç Bilim İnsanı Eğitimi ve Üstün Zeka Dergisi, 1(1),* 16- 20.

Kahoot!.(2017). Kahoot!. Retrieved October 22, 2020 from https://kahoot.com/what-is-kahoot/https://kahoot.com/ mobile-app/ .

Light D. & Keisch Polin D., (2010). Integrating *Web 2.0 Tools in to the Classroom: Changing the Culture of Learning,* EDC Center for Children and Technology New York. Retrieved October 20, 2020 from http://cct.edc.org/publications/integrating-web-20-tools-classroom-changing-culture-learning.

Özer,İ.E., Canbazoğlu Bilici, S. & Karahan, E.(2016). Fen Bilimleri Dersinde Algodoo Kullanımına Yönelik Öğrenci Görüşleri. *Trakya Üniversitesi Eğitim Fakültesi Dergisi, 6(1),* 28-40.

Parks, B. (2012). Death to PowerPoint. *Bloomberg Businessweek*. Retrieved October 20, 2020 from http://businessweek.com/.

Ramachandiran, C.R. & Mahmud, M.M. (2018). Padlet: A Technology Tool for the 21st Century Students Skills Assessment. *Proceeding Book of 1st International Conference on Educational Assessment and Policy - 1,* 8. . DOI: https://doi.org/10.26499/iceap.v1i1.81

Romero Martinez, S.J., Ordonez Camacho, X.G., Guillen-Gamez, F.D. & Bravo Agapito, J.(2020). Attitudes Toward Technology Among Distance Education Students: Validation of an Explanatory Model. *Online Learning, 24(2),* 59-75. https://doi.org/10.24059/olj.v24i2.2028.

Smartdraw. (2017). *Smartdraw*. Retrieved October 20, 2020 from https://www.smartdraw.com/ana-tomy-chart/examples/.

Strasser, N. (2014). Using Prezi In Higher Education. *Journal of College Teaching & Learning (TLC)*, *11*(2), 95-98. https://doi.org/10.19030/tlc.v11i2.8547

Tatlı, Z. (2017). *Kavram Öğretiminde Web 2.0*. Ankara : Pegem Yayıncılık.

Zengin,Y., Bars, M. & Şimşek, Ö. (2017). Matematik Öğretiminin Biçimlendirici Değerlendirme Sürecinde Kahoot! ve Plickers Uygulamalarının İncelenmesi. *Ege Eğitim Dergisi, 2(18),* 602-626.

Zohuri, B. (2020). 21st Century Technology Renascence A Driven Impacting Factor For Future Energy, Economy, Ecommerce, Education, or Any Other E-Technologies. Preprints 2020, 2020070401 (doi: 10.20944/preprints202007.0401.v1).

https://www.google.com/slides/about/

https://help.plickers.com/hc/en-us/articles/360009395854-What-is-Plickers-

https://edpuzzle.com/content

https://tr.padlet.com/

http://www.algodoo.com/

https://phet.colorado.edu/tr/accessibility

https://www.modelscience.com/chemlab.

https://www.powtoon.com/edu-home/

Intelligent Tutoring Systems and Metacognitive Learning Strategies: a Survey

Asad Raza
University of Sindh, Jamshoro

Introduction

Learning is the ultimate goal and outcome of any education activity. Students need different learning techniques for achieve better learning. Students need different strategies and teaching methods for effective learning in different domains such as mathematics, science, English, physics and not limited to these subjects. Intelligent tutoring systems are educational softaware which are used for learning purpose without inverventaiton of human tutor. Intelligent tutoring system is an extension of Computer Aided Instruction(CAI) which consists of intelligence, feedback, adaptive behavior(Reva Freedman, 2000).

Students find tutoring systems effective and helpful for leraning(Beal and et.al, 2007). A comparative analysis study of effectivnessof intelligent tutoring systems with traditional classroom hasbeen studied(Steenbergen-Hu, 2014). These systems have been developed for different domains such as Metacognitive Mathematics Tutor(Raza,2016), PHP(Weragama, 2013) Animal Watch(Carole R. Beal, 2010), Computer programming (Butz,2006),Physics(VanLehn,2005).WayangOutpost(Arroyo,2004),ActiveMath(Melis and Siekmann, 2001), SQL tutor(Mitrovic,2003), and Andes for physics(Vanlehn,2005). Hints are mostly given in intelligent in tutoring system (Raza,2016; VanLehn, 2005; Carole R. Beal, 2010; Melis, 2001; Arroyo, 2004)

Metacognition is cognition about cognition and regulation of cognition or thinking about thinking (Flavell, 1979). Metacogniton is higher level order thinking component. It is widely studied and researched that metacongionstrenghten the learning of students((Joe Garofalo, 1985). Metacognition is used to reduce cognitive load. When a teacher is asking student to remember English paragraph so he will be use its cognition but how to remember very effectively these strategies are called metacognitive learning straegires, Self explanation, Self explanation, Self Monitoirng, Self assessment, Think aloud are few examples of metacognitive learning strategies.

Students face difficulties in learning different subjects such as mathematics; so for effective learning and lifelong learning. Learning strategies has helped students in improvement of their learning(D'Ambrosio, 1995). Students which are less learner have low metacognition. Students with higher metacognitive skills are successful learners and they are aware of their cognition. Let a student say that he can remember more than 100 words so he know about his memory how his memory can retain words but when students gives a assignment to remembering English vocabulary of 100 words he could not remember 100 english vocabulary words, so we can say that that studnet metacognition is weak. Metacogniton role in learning is very important so students need to learn about metacognitve strategies.

Students will be aware about their congitoin through metacognition. Students faces any diffilcty in English or mathematics, he can use metacognition learning strategies to scaffold his learning and become better learner. These strategies are now part of teachers instuctions and students actively do practices with mecogntive strategies in classrooms(Hapsari,2020).

Learning performance of students and their metacognition have been widely researched and it has been revealed that metacognition improves the learning performance (Joe Garofalo,1985; Van derstel, 2010; Şahin, 2013). An Intelligent tutoring system with metacognitive support can en-hance the effectiveness of the tutoring system and improvesstudent learning. Metacognition role in students learning has been studied for various subjects such as like chemistry(Rowan W. Hol-lingworth,2001),HTML(kyungbinKwon,2011),SQLtutor(Najar,2013),Science(Leelawong, 2008) and Mathematics(Raza and et,al,2016).

Different metacognitive learing strategies has been used for learing. In this survey, three metacognitvelearing strategies self explanation, self questioning and self monitoring have been discussed.

Self explanation is metacognive strategy in which students explain learning material to themselves. It has been found that students learn more when explain instructional material to themselves (Chi, 1994). Students which are are better learners also cangenerate more self explanation while poor students can not generate enough self explanations (Chi, 1989).Self explanation is metacognitive strategy used in many intelligent tutoring systems and learning enviroments.Interactive learning enviroment for HTML (kyungbinKwon,2011) used self explanation to self explainduring error anddebugging phase in HTML learning, SQL tutor(Najar,2013)used self explanation to explain understanding of SQL workout examples and after solving problems. Fraction problems with self explanation(Rau, 2009),English Grammartutor with self explanations support (Wylie, 2009).Geometry explanation tutor(Aleven,2004) used two modes of self explanation one is dialoged based and other is menu based self explanation to investigate effects of learning in geometry.

Self monitoring is metacognitive learning strategy process of observing, recording and measuring performance and behaviors (Anastasia Kitsantas, 2009).Self monitoring is a step of self regulation so students can regulate their learning through self monitoring.

It has been found that students involvement in self monitoringis very effective and results in increase ofstudents achievement, probem solving skills and academic success (Schunk,1998). Self monitoring can be used to create students be self direct learners (Steven V. Shannon,2008).Self monitoring also used for English as foreign language in web based learning enviroment which results in improved academic performance(Mei-Mei Chang, 2010). TrAviswhich is Distance education learning environment with self monitoring tools also results positive from students and teachers (Madeth May, 2011).

Self questioning is self regulation strategy which is used to ask questions yourself. It is activity of internally asking questions. It focus on knowledge acquisition and comprehension monitoring by the learner generating questions and this question generation and answering will result in improving comprehension(Wong, 1985). Self questioning strategy used as effective and helpful in learning (King, 1992). Questionbank(Draaijer,2005) developed web based application for supporting self questioning, reading comprehension (Mostow,2009) and Circuit theory(Pate, 2011). Self explanation and self questiong can reduce gaming hint and student can self regulate their learning through self monitoring their performance after viewing their activities during problem solving(Raza, 2016).

Metacognition assessment is very critical task. Metacognition is internal component of students so tools and techniques have been used for metacognition assessment. In this suvery we included different questionares which are used for assessing metacogniton. Self report questionare can be easily used to assess metacognition of students. Jr MAI (Sperling, 2002) is self reportquestionnaire which target younger population. Jr MAI is used by many researchers in which their research objective is to assess metacognition.Jr MAI used as offline method to find which is more efficient for assessing metacognition skills (Seda, 2012).studentsexplored with a science website with two structures linear and non linear and investigated learning in hypermedia environment and its relation with metacognition, Jr.MAI was used to assess students metacognition (Schwartz, 2004).Effects of tutoring on students self regulated learning was investigated and Jr. MAI measure was selected for assessing student self regulated skills(Vandevelde, 2011).

Intelligent Tutoring System

Intelligent tutoring system is computer software which provide instructions to students similar to human tutor and provide feedback to students. Intelligent tutoring system term in research community first introduced by Brown (Brown, 1982) as an more innovative term for intelligent Computer Aided instruction (ICAI). Intelligent tutoring systemis an *interdisciplinary* field which includes investigations and research studies to devise strategies and learning systems through which students can get more effective and better learning as a good teachers do(Conati, 2009).

Difference between traditional computer based learning system or computer Aided instruction(CAI) and intelligent tutoring systems is that ITS provides feedback and guidance to students about their learning performance without involving of any humantutor.Intelligent tutoring system has lot of advantages, their flexibility of time and place. Student can learn at any time and location through intelligent tutoring so there is no any area limitation (VanLEHN,2011) . Intelligent tutoring systems mainly consists of four modules. These four modules are Interface module, Domain module, Student module and Tutor module.Students interaction with intelligent tutoring system is done in interface module. Graphical user interfaces are used to make more interactive and enjoyable interface for students.

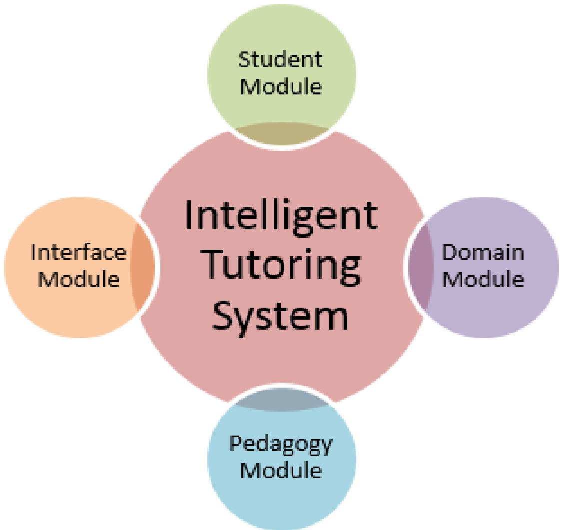


Figure 1. Intelligent Tutoring System

The Domain module is concerned with domain for which intelligent tutoring systemhasbeen designed. It includes how subject knowledge will be represented in the tutoring system.It stores and represents problems, exercises and learning content of the domain.The Student module is concerned with student progress and achievement while using tutoring system. It provides guidance and feedback to students and measure the student learning performance.The tutor moduleconcerned with pedagogy strategies for effective teaching. It is mostly concerned with student module in a way that which pedagogy or instructions system targets towhich students. Intelligent tutoring system take appropriate strategiesusing system feedback of students progress status. ActiveMath(Melis, 2001) is web based adaptive intelligent tutoring system for mathematics. Adaptive activemath provides learning material to students according to their performace, learning goals and achievement. It also produces feedback through evaluation of result progress, navigation which activemath stored in student model. Activemath provides the environment to students according to their learning condition and students are responsible for their own learning. Activemath can be used in teacher assisted learning, computer instructed insutions, home work activity and long distance learning. Wayang Outpost(Arroyo, 2004) is an intelligent tutoring system developed for Scholastic Aptitude Test(SAT) Mathematics section. Math problems are presented in flash movie and system also helps students with hint. System provides two hints one is numeric and other is multimedia such as animation with audio like drawing or highlighting a task. System results in significant improvement in mathematics learning. Mathesis(Sklavakis, 2013) is web based intelligent tutoring system for school level algebra. Mathesis consist of important component algebra tutor which provides intelligent task recognition and deep model tracing. Mathesis provides all functionalities of traditional classroom such as assignments, assessment and enrollment. Intelligent tutoring system designed for information security subject. Al Azhar university in Ghaza enrolled in information security course participated in study and evaluation of tutoring results are good(Mahdi, 2016). Oracle intelligent tutoring system(OITS) designed and developed for teaching of oracle. Researchers studied effects of intelligent tuoring system on students performance(Elnajjar,2017). Intelligent tutoring system for Introduction to computer science which is compulsory subject in Al-Azhar university have been system integrated in system, which record students program. Effects of systems on students performance was investigated and results showed positive results after students evaluation(Marouf,2018). Intelligent tutoring system for java developed and imporoved students performance after evaluation(Al-Shawwa,2019). Intelligent tutoring system for programming with 3D graphics in Augmented Reality (AR) enviroemnt has been designed(Schez-Sobrino, 2020).

Metacognition

Cognition are processes which occurs in our mind such as decision making, problem solving, remembering or comprehension. Cognition about cognition and regulation of cognition or “ thinking about thinking” is called Metacognition(Flavell, 1979).

Let understand metacognition by an example. A student said that he has good understanking and knowledge of fraction, ratios and proportions of six grade but when teacher gave him problems he did not solved and failed to solve problem or his answer was not right. Other student of English said that he could remember 50 words of English but when he do exercise of rembering English vocabulary it could not remembered 50 words. So which students that he could do that task this is students metacognition. Students did not complete their task claim herself because they did not have knowledge about their cognition or they have poor metacognition. Intelligent Students have strong metacogntion while weak students have poor metacognition. Metacognition in learning is important, so to be effective learner students should have strong metacognitoin. Students can take their own learning resposnibilty by using metacognitive strategies to know about their thinking process and regulate their own thinking. Students could self aware about themselves through metacognitive learning strategies, knows about themselves such as how well they are doing and they can improve their learning without involving of teacher. So teaching students about metacognition is very critical to students learning.

Metacognition is divided into different types according to theoretical models. Metacognition is divided into two components, Knowledge of cognition and regulation of cognition.Knowledge of cognition is self aware about their

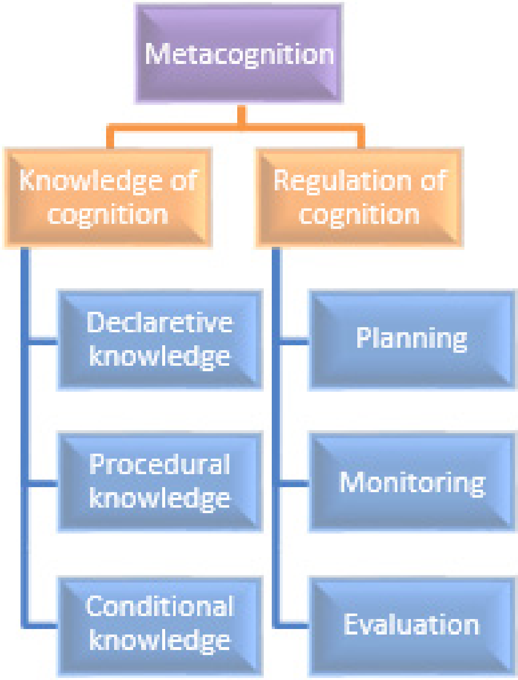


Figure 2. Metacognition

own cognition and thinking process. It includes self awareness, knowing their own thinking process. Knowledge of cognition is further divided into Declarative knowledge, Procedural knowledge and Conditional knowledge. Regulation of cognition is consists of steps to control own cognitive processes. Planning, Monitoring and Evaluating are steps involved in regulation of cognition (Metacognition, Wikipedia) .

In this survey three metacognitive learning strategies self explanation, self questioning and self monitoring have been discussed in below sections.

Self Explanation

Self explanation is metacognitive learning strategy to explain onself learning material to understand it very effectively each and every line of content(Chi, 1994). Students during reading text, workout example in mathematics explain themselves what they understood. Self explanation is activity of thinking aloud to yourself. Self explanation can be practiced on papers in class rooms and in intelligent tutoring systems in hints (Raza, 2016).

Self explanation can be defined with two processes inference generation and conceptual revision. Inference generation is used to find students learning about content and it involve struggling for new knowledge through explaining themselves content. Conceptual revision which is reflective in natures used to indentify flaws in students primary mental model with current understating to repair the students mental model of understanding which consequently transfer new knowledge (Chi, 2000).

According to cognitive load theory working memory is limited; self explanation strategy involves explanation content and this explanation generation, inference generation requires high cognitive load. Self explanation with Scaffold learning can used to reduce cognitive load and give confidence to students to generate self explanations for effective learning(Sweller,1988;Sweller, 1998). Students during problem solving activity were asked to generate self explanation and were also judged their self explanation such as high quality self explanations or low quality self explanations, students with feedback performed better in problems as compared to those students who only asked to self explanation without feedback(Cheshire, 2005). Self explanation have been integrated by different researchers for different domains such HTML(Kyungbin, 2011) and SQL(Amir, 2013). Researchers developed interactive learning environment for HTML learning. Open and scafolded self explanations promots used in HTML problem scenarios. Results shows self explanations find effective in learning, increased learning and motivations of students. Interactive Self explanation prompts has been designed for HTML learning. Open and scafolded self explanations were embedded in learning environment for HTML learning(Kyungbin,2011). Self explanations also used to write what is understood after reading examples and problem solving. SQL tutor designed for SQL domain, which consists of SQL examples with self explanations to scaffold learning(Najar, 2013). Geometry explanation tutor was designed with two types of self explanation promots, one is Dialogue based and other is menu based self explanation. Researchers found that Dialogue based self explanion were more effective than menu based self explanation (Aleven, 2004). Single graphical and multiple graphics represention were used for fraction learning. Students were prompted to self explain graphical representations. Self explaination with multiple graphical representions improved fraction learing than self explanation with single graphical representation(Rau, 2009). English Grammer Tutor with self explanations was developed for learning of English as second language(ESL). Two groups one is with self explanation and other with no self explanations were designed(Wylie,2009). Cognitive tutorwas used to investigate self explanation. Two versions of cognitive tutor was used one with scafold explanation and other without self explanation. Results showed significant improvement from pretest to posttest (Aleven,2002). Two studies was conducted first self explanation use in text reading and second is effectiveness o different self explanation promopts (Chou, 2009). Instructinal explanations of expers, teachers and tutors stand alone are not effective, so instructional explanations were combined with self explanations to scaffold students learning. SEASITE(Self explanation activity supplmeneted by instructional explanations) principle implemented to investigate mixture instructional explanations and self explanations. Prob ability problem scenarios were used to conduct study and their mixture improves students learning(Renkl,2002). Self explanation used to investiage impact on learning, cognitive load and intrinsic motivation and other factors in an interactive multimedia environment(Lin ,2016). Impact of Self-Explanation and Reading Training (SERT) for Introduction to biology course of college students studied and results showed that students with self explanation and combination of instruction improved their science learning(McNamara,2017). Open ended Self explanation strategy used in virtual laboratory learning system used and used Natural language processing(NLP) technology to classify and provide feedback of students self explanations(Huang, 2018). Self explanation used and peer instruction to imporove students physiological concepts(Versteeg, 2019).

Self Monitoring

Self monitoring is activity of recording, measuring and observing learning progress by itself. It promotes independent learning and student centered metacognitive learning strategy. Students improve their cognition through self monitoring to know *how well you am doing*; it used to control and aware of their own learning process. Self monitoring used to evaluate itself without intervention. Students can increase self efficacy beliefs by control their own learning (Zimmerman, 1995). Students can regulate their cognition through observation and measuring progress. Students can achieve their goals by changing behaviors and discovers their weakness (Anastasia Kitsantas, 2009). Warm up strategy based on self explanation and monitoring integrated with blog based learning system used to help students for better learning(Yih-rueyjuang, 2012). Metacognitive learning strategies can be used to help students self directed learners trhough integration of self management and self monitoring. Anecdotal notes, teacher student reflection and observations used to collect data. Association between learning styles and metacognitive strategies was explored(Steven v. Shannon, 2008) . Self monitoring effect on EFL studens learning performance and motivational beliefs was conducted. Self recording form was used to experiment effectiveness of self monitoring. Results showed improvement in academic performance and positive motivational beliefs (Mei, 2010). TraVis developed for students and teachers to supports students in visualization of communication actions and teachers to do adapt effective pedagogies. TraVis facilitates students for self monitoring to view all activities performance indicator or participation rate(Madeth may, 2011). Metacognitive strategies for self management such as self monitoring and self graphing used to improve math of students. Self management encourage students to take responsibilities of their own learning and monitor academic performance and other activities rather depending on teachers(Anthony Farrell, 2008). Web based learning environment used for exploring self monitoring, reflection and problem solving prompts on students performance. Study was conducted in two stages; in first students received problems solving and other group did not recieved and in second stage reflective prompts to one group and other without reflective prompts.Metacognitive Awareness Inventory (MAI) was used to assess Metacognition. Results showed that students with prompts improved their performance than without prompts. Learning achievement, self-monitoring, cognitive style, and learning style relationship is studied for medical students. 130 students participated in the study, findings explored positive relationship between achievement and cognitive style and use of metacognitive strategies(Martínez-Bernal,2016). Self monitoring effects on elementary school students with dyslexia have been studied. Results showed that students achievement increased after self monitoring training(Kanani, 2017). Self monitoring used to support instruction in classroom and results showed that self monitoring increased students academic engagement(Ennis , 2018). Effects of self monitoring on elementary students academic engagment studied. Technology based self monitoring intervention called CellF-Monitor used by students. Visual analysized explored positive effects of CellF-Monitor on academic engagement(Schardt, 2019). The relationship between motivation, self monitoring and self management have been investigated and findings explored that motivation affected self monitoring and self monitoring influenced self management so promoting self monitoring and self management skills is very criticial for learners(Zhu, M , 2020).

Self Questioning

Self questioning is metacognitive strategy is used for teaching and learning. It is used in reading, comprehension and problem solving. Self questioning is used by asking questions onself to monitor congnition which will result in regulation of congnition. This strategy involves learners to ask questiongs during problem solving or any learning activity learners. These questions and question generation technique can be used as tool to think and focus on specific topic. Self questioning effects on secondary levels students with circuit theory course problems were researched; students who practiced with self questioning strategy performed better than other group (Pate,2011). Reading tutor which generate sefl questioning instruction automatically for students to help in reading comprehension and retention. Expert pedagogy is divided into four phases describing, modeling, scaffolding and prompting the strategy. A working example was given to students to practice these phases for given text during reading comprehension (Mostow, 2009). Effectiveness of Self questioning strategy have been researched in web application Questionbook. Frst year 135 marketing students selected for research study and results explored that questionbook is supporting tool for learning (Draaijer,2005). Reading comprehesntion of science text has been studied with three strategies one of them is self questioning. 120 students participtated in study, participants divided into two groups High proficiency and low proficiency. Results shows that self questioning has positive effects on both groups (Haidee, 2014). Prose comprehension of ESL reading studied, 47 students randomay assigned control group which read text and control group read text with support of self questioning strategy. Results showed that no significant changes developed in prose comprehension and also explored that question generation require verbal ability (Miciano, 2002). Self questioning used in online medical health learning management system(Samadi, 2017). Self questioning used to improve reading comprehension of second semester students of English department(Telaumbanua, 2019). Self metacognitive questioning used to learn quantum physics problems(Dökme,2019). Experimental research have been conducted for Self questioning effects on reading comprehenstion of narrative text of Grade VIII. Results showed that strategy increased students reading comprehension(Marzuki,2020).

Metacognition Assessment

Metacognition can be assed with two measures online and offline measures. self report questionare such Junior Metacognitive awareness inventory(Jr. MAI) and teaching rating are examples of offline measure while think aloud protocol is an examples of online metacogntion assessment (Seda, 2012). Students explored Sciene website used as learning resource for two and five hours independently without intervention and their Metacognition has been assessment with Junior Metacognitive awareness inventory(Jr. MAI) and How I study Questionare(HISP) used for Metacognition assessment(Schwartz, 2004). Two studies one is Relationship between Science achievement, metacogntion and Epistemological beliefs, second is gender, socioeconomic status, Metacognition and epistemological beliefs have been studied. Junior Metacognitive awareness inventory(Jr. MAI) and Schommer epistemological belief questionare(SEQ) was used to collect data from students(Topçu,2009). Students tutoring effects on self regulated learning studied. Self regulated learning interview schedule(SRLIS) used to assed twelve self regulated learning and subscale learning motivation from Learning Motivation Test(LMT) and Jr. MAI Form B also finished by students (Vandevelde, 2011). Researchers used Motivated Strategies for Learning Questionnaire (MSLQ) to measure self monitoring and Embedded Figures Test (EFT) to measure cognitive styles (Martínez-Bernal,2016).

Conclusion

This paper presents the survey of intelligent tutoring systems, metacogntion learning strategies and metacogntion assessment. Inteliigent tutoring systems are learning software which used for learning without intervention of human tutor. Metacognitoin learning strategies used in intelligent tutoring systems, classrooms to support students learning. Self explanation, self monitoring and self questioning are metacognitive stragies which used by students and teachers to scaffold their learning. Metacogntion is inner element of mind so self report questionares used to assess metacogntion of students.

References

Aleven, V. A., & Koedinger, K. R. (2002). An effective metacognitive strategy: Learning by doing and explaining with a computer-based Cognitive Tutor. *Cognitive science, 26*(2), 147-179.

Aleven, V., Ogan, A., Popescu, O., Torrey, C., & Koedinger, K. (2004). Evaluating the Effectiveness of a Tutorial Dialogue System for Self-Explanation. In J. C. Lester, R. M. Vicario,& F. Paraguaçu (Eds.), *Proceedings of Seventh International Conference on Intelligent Tutoring Systems,* ITS 2004 (pp. 443-454). Berlin: Springer Verlag.

Al-Shawwa, M. O., Alshawwa, I. A., & Abu-Naser, S. S. (2019). An intelligent tutoring system for learning java. International Journal of Academic Information Systems Research, 3(1), 1-6.

Arroyo, I., Beal, C., Murray, T., Walles, R., & Woolf, B. P. (2004). Web-based intelligent multimedia tutoring for high stakes achievement tests. *In International Conference on Intelligent Tutoring Systems* (pp. 468-477). Berlin: Springer.

Beal, C. R., Shaw, E., & Birch, M. (2007). Intelligent tutoring and human tutoring in small groups: An empirical comparison. *Frontiers in Artificial Intelligence and Applications*, *158*, 536.

Brown, D., Sleeman, J. S., Eds. (1982). *Intelligent Tutoring Systems.Academic Press*.

Butz, C. J., Hua, S., & Maguire, R. B. (2006). A web-based bayesian intelligent tutoring system for computer programming.*Web Intelligence and Agent Systems, 4*(1), 77-97.

Beal, C. R., Arroyo, I. M., Cohen, P. R., & Woolf, B. P. (2010). Evaluation of AnimalWatch: An intelligent tutoring system for arithmetic and fractions. *Journal of Interactive Online Learning, 9*(1).

Chang, M. M. (2010). Effects of self-monitoring on web-based language learner's performance and motivation. *Calico Journal, 27*(2), 298-310.

Cheshire, A., Ball, L. J., & Lewis, C. N. (2005, July). Self-explanation, feedback and the development of analogical reasoning skills: Microgenetic evidence for a metacognitive processing account. *In Proceedings of the Twenty-Second Annual Conference of the Cognitive Science Society, ed. BG Bara, L. Barsalou & M. Bucciarelli*, (pp. 435-441)

Chi, M. T. (2000). Self-explaining expository texts: The dual processes of generating inferences and repairing mental models. *Advances in instructional psychology, 5,* 161-238

Chi, M. T. H., Bassok, M., Lewis, M. W., Reimann, P., & Glaser, R. (1989). Self-explanations: How students study and use examples in learning to solve problems. *Cognitive Science, 13*(2), 145-18

Chi, M. T. H., De Leeuw, N., Chiu, M.-H., & La Vancher, C. (1994). Eliciting Self-Explanations Improves Understanding. *Cognitive Science, 18*, 439-477

Chou, C.-Y., & Liang, H.-T.(2009). Content-Free Computer Supports for Self-Explaining: Modifiable Typing Interface and Prompting. *Educational Technology & Society, 12* (1), 121–133.

Conati, C. (2009, June). Intelligent tutoring systems: New challenges and directions. *In Twenty-First International Joint Conference on Artificial Intelligence, 9,* 2-7.

D'ambrosio, B., Johnson, H., & Hobbs, L. (1995).Strategies for increasing achievement in mathematics.*Educating everybody's children: Diverse teaching strategies for diverse learners: What research and practice say about improving achievement.* Alexandria, VA: Association for Supervision and Curriculum Development.

Dökme, İ., & Ünlü, Z. K. (2019). The Challenge of Quantum Physics Problems with Self-Metacognitive Questioning. *Research in Science Education*, 1-18.

Draaijer, S., Boter, J., & Vu, O. (2005). Questionbank: computer supported self-questioning. *IN: Proceedings of the 9th CAA Conference*, Loughborough:Loughborough University.

Elnajjar, A. E. A., & Naser, S. S. A. (2017). DES-Tutor: An Intelligent Tutoring System for Teaching DES Information Security Algorithm. *International Journal of Advanced Research and Development, 2(1), 69-73.*

Ennis, R. P., Lane, K. L., & Oakes, W. P. (2018). Empowering teachers with low-intensity strategies to support instruction: Self-monitoring in an elementary resource classroom. *Preventing School Failure: Alternative Education for Children and Youth*, *62*(3), 176-189.

Flavell, J. H. (1979).Metacognition and cognitive monitoring. *American Psychologist, 34*, 906–911.

Farrell, A., & McDougall, D. (2008). Self-monitoring of pace to improve math fluency of high school students with disabilities. *Behavior Analysis in Practice, 1*(2), 26-

35.

Freedman, R., Ali, S. S., & McRoy, S. (2000). Links: what is an intelligent tutoring system?. intelligence, 11(3), 15-16.

Garofalo, J., & Lester Jr, F. K. (1985). Metacognition, cognitive monitoring, and mathematical performance. *Journal for research in mathematics education, 16*, 163-176.

Hapsari, A. D. (2020). Metacognitive Strategy Training In The Teaching Of Reading Comprehension: Is It Effective In Efl Classroom?. *Language-Edu*, *9*(1).

Huang, Q. Z., Hsu, C. C., & Wang, T. I. (2018, July). An Open-Ended Question Self-Explanation Classification Methodology for a Virtual Laboratory Learning System. In *2018 7th International Congress on Advanced Applied Informatics (IIAI-AAI)* (pp. 232-237). IEEE.

Hollingworth, R. W., & McLoughlin, C. (2001). Developing science students' metacognitive problem solving skills online. *Australasian Journal of Educational Technology, 17*(1), 50-63.

Juang, Y. R., Chou, C. Y., & Chan, J. (2012). Designing self-monitoring warm-up strategy with blog-based learning system to support knowledge building. *Knowledge Management & E-Learning: An International Journal, 4*(1), 78-87.

Kanani, Z., Adibsereshki, N., & Haghgoo, H. A. (2017). The effect of self-monitoring training on the achievement motivation of students with dyslexia. *Journal of Research in Childhood Education*, *31*(3), 430-439.

King, A. (1992). Comparison of self-questioning, summarizing, and notetaking-review as strategies for learning from lectures.*American Educational Research Journal, 29*(2), 303-323.

Kitsantas, A., & Dabbagh, N. (2013). *Learning to Learn with Integrative Learning Technologies (ILT): A Practical Guide for Academic Success*. IAP.

Kurt Vanlehn (2011). The Relative Effectiveness of Human Tutoring, Intelligent Tutoring Systems, and Other Tutoring Systems. *Educational Psychologist, 46*(4), 197-221

Kwon, K., Kumalasari, C. D., & Howland, J. L. (2011). Self-Explanation Prompts on Problem-Solving Performance in an Interactive Learning Environment. *Journal of Interactive Online Learning, 10(*2).

Leelawong, K., & Biswas, G. (2008). Designing learning by teaching agents: The Betty's

Brain system. I*nternational Journal of Artificial Intelligence in Education, 18*(3), 181-208.

Lin, L., Atkinson, R. K., Savenye, W. C., & Nelson, B. C. (2016). Effects of visual cues and self-explanation prompts: empirical evidence in a multimedia environment. *Interactive Learning Environments*, *24*(4), 799-813.

May, M., George, S., & Prévôt, P. (2011). TrAVis to enhance students' self-monitoring in online learning supported by computer-mediated communication tools. *Computer Information Systems and Industrial Management Applications, 3,* 623-634.

Mahdi, A. O., Alhabbash, M. I., & Naser, S. S. A. (2016). An intelligent tutoring system for teaching advanced topics in information security. *World Wide Journal of Multidisciplinary Research and Development, 2*(12), 1-9.

Marouf, A., Yousef, M. K. A., Mukhaimer, M. N., & Abu-Naser, S. S. (2018). An Intelligent Tutoring System for Learning Introduction to Computer Science.

Martínez-Bernal, J., Sanabria Rodríguez, L. B., & López-Vargas, O. (2016). Relationships between learning achievement, self-monitoring, cognitive style, and learning style in medical students. *Praxis & Saber*, *7*(14), 141-164.

Marzuki, m. (2020). Improving students'reading comprehension in narrative text of viii grade at smpn 3 tolitoli through self-questioning strategy. *Jurnal madako education*, *4*(5).

McNamara, D. S. (2017). Self-explanation and reading strategy training (SERT) improves low-knowledge students' science course performance. *Discourse Processes*, *54*(7), 479-492.

Melis, E., & Siekmann, J. (2004, June). Activemath: An intelligent tutoring system for mathematics. In *International Conference on Artificial Intelligence and Soft Computing* (pp. 91-101). Berlin: Springer.

Metacognition, Wikipedia; Retrieved from: https://en.wikipedia.org/wiki/Metacognition)

Miciano, R. Z. (2002). Self-questioning and prose comprehension: A sample case of ESL reading. *Asia Pacific Education Review, 3*(2), 210-216.

Mitrovic, A. (2003). An intelligent SQL tutor on the web. *International Journal of Artificial Intelligence in Education, 13*(2), 173-197

Mostow, J., & Chen, W. (2009).Generating Instruction Automatically for the Reading Strategy of Self-Questioning. *In AIED*, 465-472.

Najar, A. S., & Mitrovic, A. (2013). Examples and Tutored Problems: How Can Self-Explanation Make a Difference to Learning?.In *Artificial Intelligence in Education* (pp. 339-348).Berlin: Springer.

Pate, M. L., & Miller, G. (2011).Effects of Regulatory Self-Questioning on Secondary-Level Students' Problem-Solving Performance.*Journal of Agricultural Education, 52*(1), 72-84.

Rau, M. A., Aleven, V., &Rummel, N. (2009). Intelligent Tutoring Systems with Multiple Representations and Self-Explanation Prompts Support Learning of Fractions.*International Conference on Artificial Intelligence in Education* (pp. 441-448).Netherlands, Amsterdam: IOS Press.

Raza, A., Kazi, H., &Nizamani, M. A. (2016). Metacognitive Mathematics Tutor: Mathematics Tutoring System with Metacognitive Strategies. *International Journal of Computer Applications*, *975*, 8887.

Renkl, A. (2002). Worked-out examples: Instructional explanations support learning by self-explanations. *Learning and instruction, 12*(5), 529-556.

Şahın̈, S. M., & Kendir, F.(2013).The effect of using metacognitive strategies for solving geometry problems on students' achievement and attitude.*Educational Research and Reviews, 8*(19), 1777-1792.

Samadi, D. (2017). *Self-Explanation and Self-Questioning Prompts in Online Medical Health Learning* (Doctoral dissertation) Simon Fraser University, Canada.

Schardt, A. A., Miller, F. G., & Bedesem, P. L. (2019). The effects of CellF-monitoring on students' academic engagement: a technology-based self-monitoring intervention. *Journal of Positive Behavior Interventions*, *21*(1), 42-49.

Schez-Sobrino, S., Gmez-Portes, C., Vallejo, D., Glez-Morcillo, C., & Redondo, M. Á. (2020). An Intelligent Tutoring System to Facilitate the Learning of Programming through the Usage of Dynamic Graphic Visualizations. *Applied Sciences*, *10*(4), 1518.

Schunk, D. H., & Zimmerman, B. J. (Eds.). (1998). *Self-regulated learning: From teaching to self-reflective practice*. Guilford Press.

Schwartz, N. H., Andersen, C., Hong, N., Howard, B., & Mcgee, S. (2004). the influence of metacognitive skills on learners 'memory of information in a hypermedia environment. *Journal of Educational Computing Research, 31*(1), 77-93.

Seda Saran, Sema Karakelle (2012).Online and Offline Assessment of metacognition. *International Electronic Journal of Elementary Education, 4*(2), 301,315

Sklavakis, D., & Refanidis, I. (2013). Mathesis: An Intelligent Web-Based Algebra Tutoring School. *International Journal of Artificial Intelligence in Education, 22*(4), 191-218.

Sperling, Howard, Miller, & Murphy (2002).Measures of Children's Knowledge and Regulation of Cognition.*Contemporary Educational Psychology, 27*, 51–79 (2002).

Steenbergen-Hu, S., & Cooper, H. (2014).A meta-analysis of the effectiveness of intelligent tutoring systems on college students' academic learning.*Journal of Educational Psychology, 106*(2), 331.

Shannon, S. V. (2008). Using metacognitive strategies and learning styles to create self-directed learners. *Institute for Learning Styles Journal, 1*(1), 14-28.

Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. *Cognitive Science, 12*(2), 257-285.

Sweller, J., Van Merrienboer, J. J., & Paas, F. G. (1998).Cognitive architecture and instructional design.*Educational psychology review, 10*(3), 251-296.

Telaumbanua, Y. A. (2019). Self-questioning strategy to improve reading comprehension skills of the second semester students of the English Department in IKIP Gunungsitoli year 2008/2009. *SKRIPSI Mahasiswa UM*.

Topçu, M. S., & Yilmaz-Tüzün, Ö. (2009).Elementary students' metacognition and epistemological beliefs considering science achievement, gender and socioeconomic status.*İlköğretim Online*, *8*(3).

Van Der Stel, M., Veenman, M. V., Deelen, K., & Haenen, J. (2010). The increasing role of metacognitive skills in math: a cross-sectional study from a developmental perspective. *ZDM, 42*(2), 219-229.

Vandevelde, S., Van Keer, H., & De Wever, B. (2011).Exploring the impact of student tutoring on at-risk fifth and sixth graders' self-regulated learning.*Learning and Individual Differences, 21*(4), 419-425.

Vanlehn, K., Lynch, C., Schulze, K., Shapiro, J., Shelby, R.(2005).The Andes Physics Tutoring System: Lessons Learned. *International Journal of Artificial Intelligence in Education, 15* (3)

Versteeg, M., van Blankenstein, F. M., Putter, H., & Steendijk, P. (2019). Peer instruction improves comprehension and transfer of physiological concepts: a randomized comparison with self-explanation. *Advances in Health Sciences Education*, *24*(1), 151-165

Weragama, D., & Reye, J. (2013).The PHP intelligent tutoring system.*Artificial Intelligence in Education* (pp. 583-586). Springer Berlin Heidelberg.

Wong, B. Y. (1985). Self-questioning instructional research: A review. *Review of Educational Research, 55*(2), 227-268.

Wylie, R., Koedinger, K. R., & Mitamura, T. (2009). Is self-explanation always better? The effects of adding self-explanation prompts to an English grammar tutor. In *Proceedings of the 31st annual conference of the Cognitive Science Society* , 1300-1305.

Zhu, M., Bonk, C. J., & Doo, M. Y. (2020). Self-directed learning in MOOCs: exploring the relationships among motivation, self-monitoring, and self-management. *Educational Technology Research and Development*, 1-21.

Zimmerman, B. J., & Paulsen, A. S. (1995). Self-monitoring during collegiate studying: An invaluable tool for academic self-regulation. *New directions for teaching and learning, 63*, 13-27.

SECTION 2
MATHEMATICS EDUCATION

Mathematical Remedial Lesson Plan in Teaching Learning Process at University Level: Dihedral Group

Vineet Bhatt
Graphic Era Hill University
Nandini Sharma
Graphic Era Hill University

Introduction

In every university, learning of modern algebra for undergraduate students of mathematics is to the point and understanding the coursework is application based. Many researchers state that lecture-based mathematics instruction is unapproachable and confusing to students about the nature of mathematics, especially in modern algebra proof-based course for undergraduate and postgraduate students. It is believed by some lecturers in our mathematics department that the low performances of students opting this course is connected with the fact that progressing from the concrete situations of elementary algebra in high school to the more abstract algebra of undergraduate studies is usually a complicated transition for many students. Most students were able to demonstrate a modicum of aptitude in elementary algebra at high school, the majority fail to acquire a solid conceptual understanding of the abstract algebra offered at university level. The usual focus of mathematical activities in high school is on manipulations of symbols to find particular numerical answers. In contrast, abstract algebra requires students to think in terms of the structure of problems rather than in terms of operations. It involves procedures, interpreting and understanding relationships and expressing them in general simplified form. The following question now emerges: how could one improve students understanding of abstract algebra offered at university level? The author believes that any improvement in understanding could involve the incorporation of new lecture plan, such as general purpose and readily available basic logic of content in teaching. In this paper, our purpose is to sort out the problem of those students, who are pursuing their undergraduate, postgraduate and students who wish to do specialized education after a long gap or are coming from another stream. The purpose of this paper is to create a lesson plan on the specific topic dihedral group for those students who have not understood the basic logic of modern algebra. Here the author also discusses about situation that arises in the class room during delivering the lecture at post-graduation level, that the teacher instructs from the front of the room while the students sat in desk arranged to face the board, here the teacher is not aware about students previous knowledge regarding the subject as put up earlier that the students are based from different field or are perusing the degree after a long gap, resulting in no student participation in the classroom. As a result, student lags behind and creates high failure rate in the course.

Literature Review

The following section describes various aspects of the study in mathematical learning with a brief literature survey. (Goodchild, S., 2020) put forward a book on philosophy of mathematics education today. (Chen & Wu, 2020) studying how to effectively implement remedial instruction in mathematics education. Results of this paper showed that when ICT-integrated mathematics remedial instruction was not implemented, students' scores in the post test were not significantly higher; however, after implementing ICT-integrated mathematics remedial instruction, the grades in the post test were significantly higher. The results may facilitate the application of technology to implement mathematics remedial instruction. A survey on word problems in mathematics education had proposed by (Verschaffel et al., 2020). Word problems are among the most difficult kinds of problems that mathematics learner's encounter. Perhaps as a result, they have been the object of a tremendous amount research over the past 50 years. This opening article gives an overview of the research literature on word problems solving, by pointing to a number of major topics, questions, and debates that have dominated the field. Author (Verschaffel et al., 2020)., also review research on the impact of three important elements of the teaching-learning environment on the development of learners' word problem solving competence: textbooks, software, and teachers. The article (Erbilgin, 2019). investigates how collegial lesson preparation and reflection that focuses on prospective teachers' thoughts supported the participation of mathematics teacher educators' perspectives on teaching and learning. In this paper the data sources incorporated weekly planning and reflection meetings, activity worksheets, reflective journals, and audio recordings of lessons. Data analyses revealed that engaging in this action, research provides the contribution of teacher educators with opportunities, to discuss important issues for mathematics teacher educators and improved their skills in lesson planning and implementing. The interrelationship between Mathematics and development of humans to advance the cause of humans is a fundamental significance of Mathematics to humans has been described by (Brijlall, 2020). The author draws on many empirical studies which address quality in teaching and learning. The focus is to summarize many research studies which deal with the teaching and learning of Mathematics in Higher Education. Author (Cohen, 2018), point up that Education is a complex process involving teachers and learners within surrounding institutional and social environments over which neither group has extensive control. However, complexity is not an excuse for despair or inactivity. In particular, there is an attractive intellectual challenge involved in finding accessible and engaging ways to help teachers understand the mathematics itself. With the reference of article (Novak et al., 2017), author describes students' perspectives of a one-off flipped lecture in a large undergraduate mathematics service course. The focus was on calculating matrix determinants and was designed purposely to introduce debate and argumentation into a mathematics lecture. The intention of the author (Novak et al., 2017) was to promote a deeper learning and understanding through engagement with the added hope of instilling some passion for the subject. Within this paper, authors (Novak et al., 2017) share the data and reveal the interesting results that emerged from their analysis. This article (Wasserman et al., 2016), explores the potential for aspects of abstract algebra to be influential for the teaching of school algebra. Author (Wasserman et al. 2016) using national standards for analysis, four primary areas common in school mathematics and their development across elementary, middle and secondary mathematics, where teaching may be transformed by teachers' knowledge of abstract algebra are developed. Author (Pimm et al. 2019) has presented an impressive book titled "Speaking Mathematically". The author with reference to piece of writing (Johnson et al., 2018) says, in the United States, there is significant interest from policy boards and funding agencies to change students' experiences in undergraduate mathematics classes. Author (Johnson et al., 2018) conducted a national survey of abstract algebra instructors at Master's and Doctorate-granting institutions in the United States to investigate teaching practices, to identify beliefs and contextual factors that support the constrain of non-lecture teaching practices, and to identify commonalities and differences between those who do and do not lecture. This work provides insight into how abstract algebra is taught in the United States, for how to approach and better support those who are interested in implementing non-lecture teaching approaches. In this article (Park et. Al., 2018) author says, developmental education became optional for many college students in Florida, regardless of prior academic preparation. This study investigated first-semester math course enrolment patterns for underprepared first-time-in-college students, who would have previously been required to take developmental math and the passing rates for the students electing to take Intermediate Algebra. Development of mathematical connection skills in a dynamic learning environment have described by (Zengin, 2019). Author's purpose of this study was to examine the effect of GeoGebra software on pre-service teachers' mathematical connection skills. After GeoGebra implementations, the quantitative data were analysed using a dependent t-test and the qualitative data obtained with the open-ended questionnaire were analysed using descriptive analysis. Based on the results, it was determined that GeoGebra software could be used as an important tool for the development of mathematical connection skills. Author (Orcos et al., 2019) describes the development of an application that allows compulsory secondary education teachers the assessment of the students' maths competence. The results of this paper (Orcos et al., 2019) gathered throughout speaking tasks, tests and work done by students in 2nd, 3rd and 4th course of compulsory Secondary Education of a state school in Spain. Research in article (Breen et al. 2019) has shown that the types of tasks assigned to students affect their learning. Various authors have described desirable features of mathematical tasks or of the activity they initiate. Others have suggested task taxonomies that might be used in classifying mathematical tasks. The masterpiece (Sinan & Zekeriya,

2018) related to the study of developing a lesson plan for the "Graphics and Animation in Education" course lectured in the department of Computer Education and Instructional Technology. The basic strategy used by author for this course is stated as "Expository" and during the course demonstration question-and-answer methods were used. Resulting author (Sinan & Zekeriya, 2018) developed a unit lesson plan for graphics and animation in education course. Article (Nuchanart et al., 2014) propose an experimental result with target group of students using 11 lesson plans for mainly focusing on development of lesson plans, development of the students thinking skills and study the student's opinions and also have an observation test form and achievements test with emphasis on thinking skills. The criteria with reference to article (Marcia & Gayani 2010), author explains that effective teaching in higher education is understood to comprise particular skills and practices applied within particular contexts. The paper maintains that our collective understanding of competent, professional and effective teaching must repeatedly evolve in order that it accurately reflects and responds to the contexts in which learning and teaching is undertaken. The author referencing article (Saa et al., 2019) expresses his view that, predicting the students' performance has become a challenging task due to the increasing amount of data in educational systems and also showed that the most common factors are grouped under four main categories, namely students' previous grades and class performance, students' e-Learning activity, students' demographics, and students' social information. In this paper, authors have presented a comprehensive survey based on the student's frail learning on selected topic "Dihedral Group". The rest of the paper is organized as follows. Section 2 gives an overview of the survey on problem analysis throughout the lecture. The design of remedial lesson plan is presented in section 3. Section 4, is associated to evaluation and discussion. Conclusion with acknowledge and references are given in section 5.

Problem Analysis During Lecture Process

Any lecturer organises and presents a lecture of abstract algebra on the topic: dihedral group. "A dihedral group is a group of symmetries of regular polygon which involves rotations and reflections. The dihedral group is an example of a finite group and plays an important role in group theory, geometry and chemistry. Dihedral group basically represented by, is a group of order 2n. A regular polygon with n sides has different symmetries i.e. rotational symmetries and reflection symmetries." After introducing the topic during the lecture few questions were asked to the students to know their understanding. The three different questions were break-down on the aspects as: previous knowledge, about group and order of the group.

After delivering the lecture on the topic dihedral group, the lecturer asked some questions to the students for evaluating their previous knowledge and understanding level.

Lecturer: Why (a set of all rotational and reflection of a polygon) is said a dihedral group?

Student: Because the set satisfies all properties of a group.

Lecturer: What is a regular polygon?

Student: A regular polygon is a closed figure with all sides of same length and all angles are of equal measurement.

Lecturer: (To another student) what properties are necessary for a set to be a group?

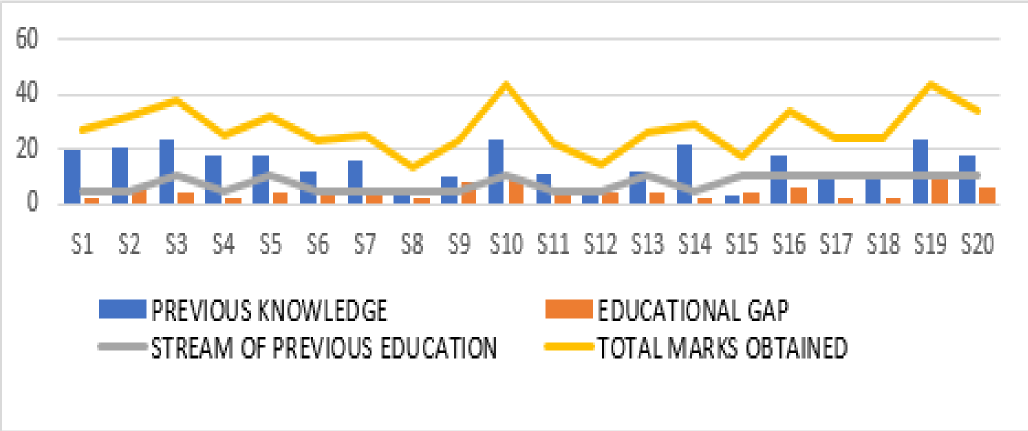
(Out of 20 students only 14 students gave right answer other didn't know about the group).

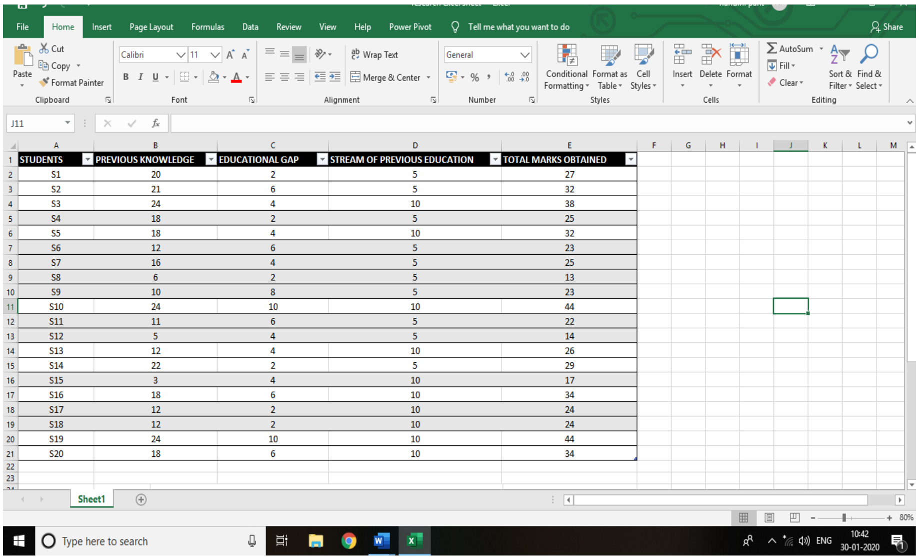
Lecturer: What is the order of a group?

(Only 11 students gave correct answer).

Now here a question strikes to the teacher that why all students are unable to answer questions based on basic Morden algebra and group theory. Before delivering the lecture, lecturer plans to take a survey to know the actual problem of those students who were unable to understand the basic concept based on modern algebra. Here the lecturer has organised a survey with 20 students to get clear idea on aspects namely pervious knowledge regarding the topic, education qualification of the student and student's education stream, on bases of their marks and percentage which is stated in table 1. Based on these aspects the lecturer will record student's marks as per there scoring out of 24 marks in the first aspect i.e. previous knowledge. With the second aspect the evaluation of marks are on the bases of there education gap, as the students with gap of 00-01 years is given 10 marks, students with gap of 00-02 years is given 8 marks, students with gap of 00-04 years is given 6 marks, year gap with 00-06 is given 4 marks, year gap with 00 -08 is given 2 marks and lastly year gap of 00-10 years is given 0 marks. Lecturer takes the 3rd condition for evaluation i.e. students coming from different stream of education, are categories in two ways i.e. students with same stream are given 10 marks and students with different stream are given 05 marks. Later on, based on total marks of each student. Lecturer has done the total evaluation and has planned remedial lesson plan for student's scoring 25 marks and below. The survey helps to design a good remedial plan for student's betterment and easy learning of the topic. Here the table 1 and the survey graph figure 1 gives us the clear understanding:

Table 1. Students Survey Table.





STUDENTS	PREVIOUS KNOWLEDGE	EDUCATIONAL GAP	STREAM OF PREVIOUS EDUCATION	TOTAL MARKS OBTAINED
S1	20	2	5	27
S2	21	6	5	32
S3	24	4	10	38
S4	18	2	5	25
S5	18	4	10	32
S6	12	6	5	23
S7	16	4	5	25
S8	6	2	5	13
S9	10	8	5	23
S10	24	10	10	44
S11	11	6	5	22
S12	5	4	5	14
S13	12	4	10	26
S14	22	2	5	29
S15	3	4	10	17
S16	18	6	10	34
S17	12	2	10	24
S18	12	2	10	24
S19	24	10	10	44
S20	18	6	10	34

Figure 1. Survey Graph

Design of the Lesson Plan on Dihedral Group with Graphical and Example Based Approach

Dear students, first we all should know about various basic terms which are important for learning of dihedral group. But before we start are topic, we will see those terms that will help us comprehend our topic more evidently.

Symmetry

In mathematics, symmetry is a property of an object that is invariant under some transformations, including translation. reflection and rotation or scaling.

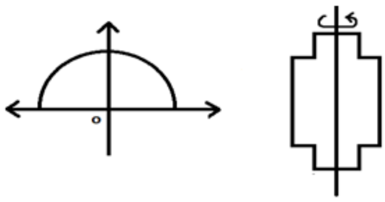


Figure 2. Symmetry About the Horizontal Axis.

A geometric object is symmetric if it divides two or more identical pieces that are arranged in an organized approach. Both semi-circle and blade in fig. 2 are symmetric about horizontal axis.

Reflection symmetry

Reflection symmetry is a type of symmetry which is with respect to reflections. Reflection symmetry is also known as line symmetry or mirror symmetry. If there exists at least one line that divides a figure into two halves such that one-half is the mirror image of the other half.

- The line where a mirror can be kept so that one-half appears as the reflection of the other is called the line of symmetry.
- A figure can have one or more lines of reflection symmetry.
- The line of symmetry can be in any direction.

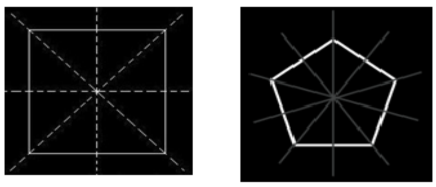


Figure 3. Line of ″ymmetry in any µirection".

Rotational Symmetry

If a figure is rotated around a center point and it still appears exactly as it did before the rotation, it is said to have rotational symmetry. A number of shapes like squares, circles, regular hexagon, etc. have rotational symmetry.

There are many shapes you will see in geometry which are symmetrical rotationally, such as:

- Equilateral triangles, Squares, Rectangles, Circles, Regular Polygons

Order of Rotational Symmetry

The number of positions in which a figure can be rotated and still appears exactly as it did before the rotation, is called the order of symmetry. For example in fig 4, a star can be rotated 5 times along its tip and look at the same every time. Hence, its order of symmetry is 5. Similarly, the recycle logo has an order of symmetry of 3 and the triangle has an order of symmetry of 3.

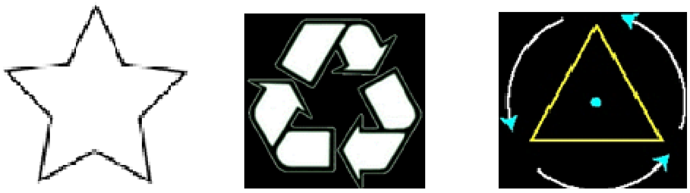


Figure 4. Order of Rotational Symmetry

Regular polygon

A regular polygon is a polygon that is equiangular (all angles are equal in measure) and equilateral (all sides have the same length) or if all the sides and interior angles of the polygon are equal, then it is known as a regular polygon.

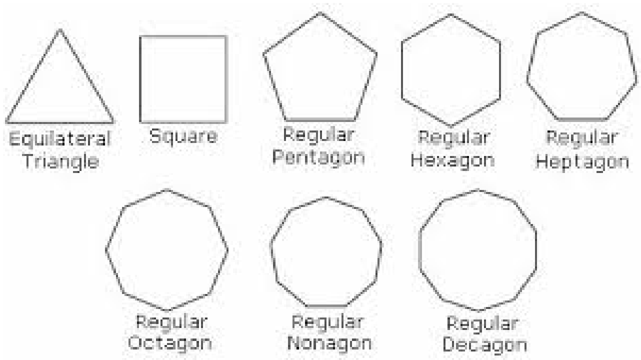


Figure 5. Regular Polygon

Group

A set equipped with a binary operation G= {S, o} where S is an non-empty set and o is operation, is called group if it satisfies four properties as,

a. Closure property: a o b = c ∀ a, b, c ∈ S.
b. Associative property: a o (b o c) = (a o b) o c.
c. Existence of identity: a o I = a = i o a ∀ a, i ∈ S, where I is an identity element.
   Identity element is an element of a group, which leaves any element at the set unchanged when combined with it.
d. Existence of inverse: a o a^{-1} = i = a^{-1} o a.

Symmetric Group

The symmetric group is the group of permutations on *n* objects. The group operation on is composition of functions. In simple words we find a group of symmetric shape by rotating and flipping the pattern known as symmetric group and is denoted by (Gallian, 2010).

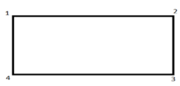


Figure 6. Symmetry of Rectangle

Here as we can observe that this rectangular has equal angles but does'nt have equal sides. So only by flipping the rectangluar horizontally and vertically we get to see its symmetry. Seeing fig.(7) flipping the rectanglur pattern, we get the same symmtery.

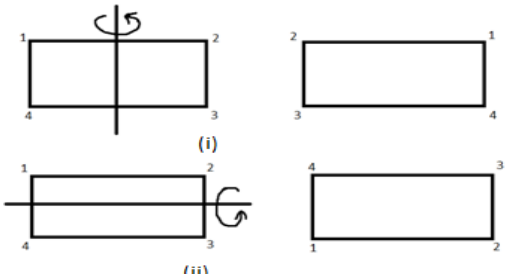


Figure 7. Vertical (i) & Horizontal (ii) Flipping

According above flipping of rectangle we get a set of all possible symmetry:

$$S_1 = \left\{ \begin{pmatrix} 1 & 2 & 4 & 3 \\ 2 & 1 & 3 & 4 \end{pmatrix}, \begin{pmatrix} 1 & 2 & 4 & 3 \\ 4 & 3 & 1 & 2 \end{pmatrix} \right\}$$

Let us take another example of an arrow pattern in which by flipping (reflection), the pattern here only one symmetry is obtained.

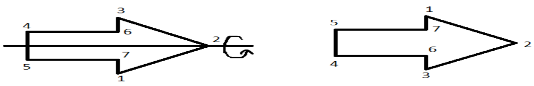


Figure 8. Reflection of Arrow

$$S_2 = \left\{ \begin{pmatrix} 1 & 2 & 3 & 4 & 5 & 6 & 7 \\ 1 & 2 & 3 & 4 & 5 & 6 & 7 \end{pmatrix}, \begin{pmatrix} 1 & 2 & 3 & 4 & 5 & 6 & 7 \\ 3 & 2 & 1 & 5 & 4 & 7 & 6 \end{pmatrix} \right\}$$

is the set of the pattern and only two elements are possible for this pattern. As every angle is different in this, so as a result there is no angular rotation.

Theoretical Framework of Dihedral Group

The group of symmetries of an n-sided regular polygon for $n > 3$ with rotations and reflections is termed Dihedral group, which is denoted as D_n. The word dihedral means two phases, and if we have a polyhedral it means many phases. The symmetry of the dihedral group depends on two types of symmetries (i) Rotation about an angle, such as figure looks same, (ii) Flipping (i.e. reflections) about the sides. The rotation of an angle depends on number of sides a regular polygon i.e. the size of angle of rotation = $\frac{360^0}{n}$ radian, where n is the number of sides a regular polygon (Gallian, 2010).

$$\text{Where } D_n = \left\{ \begin{matrix} x, x^2 = e \\ y^1, y^2, \ldots\ldots, y^{n-1} \\ xy^1, xy^2, \ldots\ldots, xy^{n-1} \end{matrix} \right\}$$

The order of the Dihedral group is $2n$. It is also known as permutation group. The set of all possible symmetry of equilateral triangle is known as dihedral group D_3. The dihedral group D_3 has order 6=(2(3)), which is found by six symmetries of an equilateral triangle.

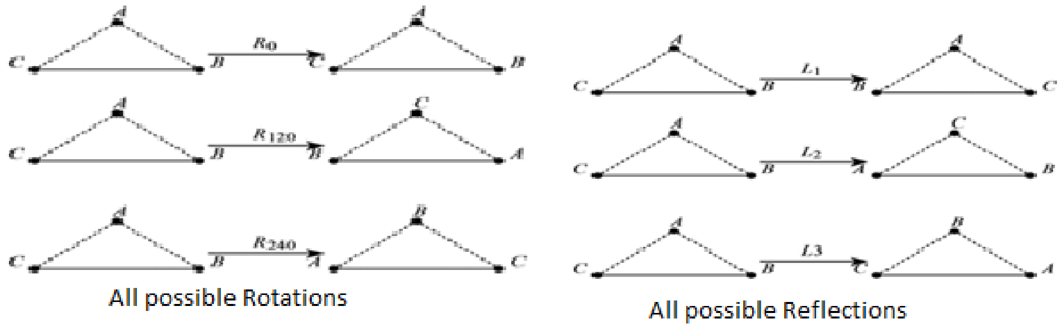


Figure 9. All Possible Ways of Rotations and Reflections for Equilateral Triangle.

The multiplication-table of D_3 is:

$(D_3,0)$	R_0	R_{120}	R_{240}	L_1	L_2	L_3
R_0	R_0	R_{120}	R_{240}	L_1	L_2	L_3
R_{120}	R_{120}	R_{240}	R_0	L_3	L_1	L_2
R_{240}	R_{240}	R_0	R_{120}	L_2	L_3	L_1
L_1	L_1	L_2	L_3	R_0	R_{120}	R_{240}
L_2	L_2	L_3	L_1	R_{240}	R_0	R_{120}
L_3	L_3	L_1	L_2	R_{120}	R_{240}	R_0

Order of Dihedral Group

The dihedral group is denoted as D_n or D_{2n} and is generated by two elements. We can basically represent these elements by x and y, in which x is one element of order 2 and y is another element of order n. We can understand this condition by eq. (1). On the bases of element order of dihedral group, the relation defined is $D^n=\{x,y :x^2=e,yx=xy^{-1}\}$

Symmetric Group Generated by a Square

The eight transformations of a square shown below form the dihedral group D_4 with 8 elements. Transformations 2, 3, and 4 are counter clockwise rotations by 90°, 180°, and 270° respectively. Transformations 5 and 6 are vertical and horizontal reflections, while transformations 7 and 8 are reflections across the two diagonals of the square. Considering the examples of a regular polygon i.e. square, which symmetries set shows a group i.e. dihedral group of order 8. As we know that a square has four sides and angle between each adjoint sides are 90 degree, therefore we can find the angular rotation and reflections of this pattern.

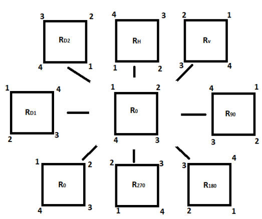


Figure 10. All Possible Symmetry of a Square

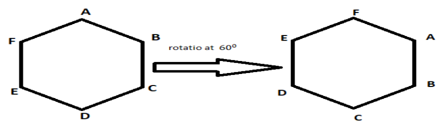
Initially we will first rotate this square at 90° degree i.e. $R_0^0 \rightarrow R90^\circ$ and the element is R_{90}°. Second angular rotation in 180° is $R_0^\circ \rightarrow R_{180}^\circ$, third is $R_0^\circ \rightarrow R_{270}^\circ$. On rotating $R_0^\circ \rightarrow R_{360}^\circ$, we get our initial patter i.e. R_0^0. Hence we will now flip (reflection) the pattern with respect to principle diagnoal i.e. D_1 , Reflection with respect to second principle diagnoal is D_2 , Refelection of the pattern horzontally i.e. R_H and Reflection on vertical axes is R_Y. Symmetry of rectangluar polygon is

$$D_4 = \left\{ \begin{matrix} \begin{pmatrix} 1 & 2 & 3 & 4 \\ 1 & 2 & 3 & 4 \end{pmatrix}, \begin{pmatrix} 1 & 2 & 4 & 3 \\ 4 & 1 & 3 & 2 \end{pmatrix}, \begin{pmatrix} 1 & 2 & 4 & 3 \\ 3 & 4 & 2 & 1 \end{pmatrix}, \begin{pmatrix} 1 & 2 & 3 & 4 \\ 2 & 3 & 4 & 1 \end{pmatrix}, \\ \begin{pmatrix} 1 & 2 & 4 & 3 \\ 3 & 2 & 4 & 1 \end{pmatrix}, \begin{pmatrix} 1 & 3 & 2 & 4 \\ 1 & 3 & 4 & 2 \end{pmatrix}, \begin{pmatrix} 1 & 2 & 3 & 4 \\ 4 & 3 & 2 & 1 \end{pmatrix}, \begin{pmatrix} 1 & 2 & 3 & 4 \\ 2 & 1 & 3 & 4 \end{pmatrix} \end{matrix} \right\}$$

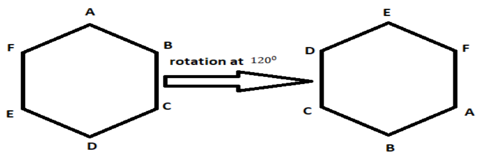
S is the set that denotes all the possible elements of rectangular polygon, and values of this polygon is written as = { I , (1 4 3 2) ,(1 3) (2 4) , (1 2 3 4) , (1 3) (2) (4), (1)(3)(2 4), (1 4) (2 3) ,(1 2) (3 4) }

(D_4, o)	R_{0^0}	R_{90^0}	R_{180^0}	R_{270^0}	R_{D1^0}	R_{D2^0}	R_{H^0}	R_{V^0}
R_{0^0}	R_{0°	R_{90°	R_{180°	R_{270°	R_{D1°	R_{D2°	R_{H°	R_{V°
R_{90^0}	R_{90°	R_{180°	R_{270°	R_{0°	R_{V°	R_{H°	R_{D1°	R_{D2°
R_{180^0}	R_{180°	R_{270°	R_{0°	R_{90°	R_{D2°	R_{D1°	R_{V°	R_{H°
R_{270^0}	R_{270°	R_{0°	R_{90°	R_{180°	R_{H°	R_{V°	R_{D2°	R_{D1°
R_{D1^0}	R_{D1°	R_{H°	R_{D2°	R_{V°	R_{0°	R_{180°	R_{90°	R_{270°
R_{D2^0}	R_{D2°	R_{V°	R_{D1°	R_{H°	R_{180°	R_{0°	R_{270°	R_{90°
R_{H^0}	R_{H°	R_{D2°	R_{V°	R_{D1°	R_{270°	R_{90°	R_{0°	R_{180°
R_{V^0}	R_{V°	R_{D1°	R_{H°	R_{D2°	R_{90°	R_{270°	R_{180°	R_{0°

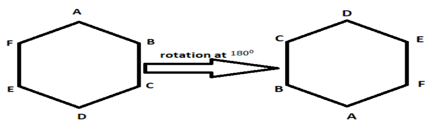
Example based on order of dihedral group of a regular polygon :



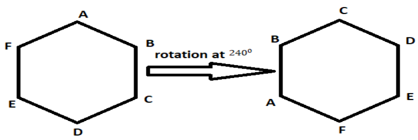
So rotation of R_0^0 polygon at an angle of 60^0 i.e. $R_0^0 \rightarrow R_{60}^0$



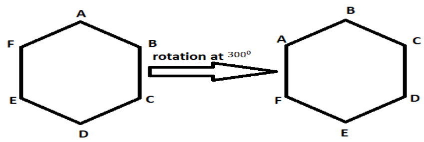
Rotation of R_0^0 polygon at an angle of 120^0 i.e. $R_0^0 \rightarrow R_{120}^0$



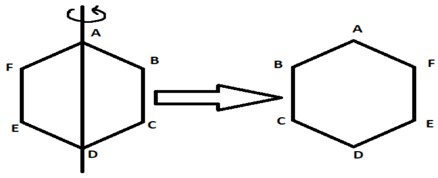
Rotation of R_0^0 polygon at 180^0 i.e. $R_0^0 \rightarrow R_{180}^0$



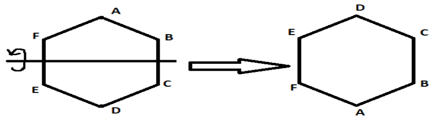
Rotation of R_0^0 polygon at an angle of 240^0 i.e $R_0^0 \rightarrow R_{240}^0$



Rotation of R_0^0 polygon at an angle of 300^0 i.e. $R_0^0 \rightarrow R_{300}^0$



Reflection of R_0^0 polygon at vertical axis i.e. $R_0^0 \rightarrow R_V$.



Reflection of R_0^0 polygon at horizontal axis i.e. $R_0^0 \rightarrow R_H$.Therefore, the reflection and rotation set/order formed for a rectangular polygon is:

$$S = \{R_0^0, R_{60}^0, R_{120}^0, R_{180}^0, R_{240}^0, R_{300}^0, R_V, R_V.R_{60}^0, R_V.R_{120}^0, R_V.R_{180}^0, R_V.R_{240}^0, R_V.R_{300}^0\}$$

Evaluation

Commonly evaluation process of any course is conducted at the end of semester or the topic. As in the case of remedial lesson plan, our assessment process is conducted at the completion of our topic with a different logical aspect. Based on the learning outcome of the topic, lecturer categorizes few questions for students in two parts as one question related to topic and other is application based which is necessary to evaluate at higher education level. We observe that after delivering such type of remedial lesson plan, the knowledge of student had improved then what it was earlier.

Discussion

Many researchers work on children mathematical learning disabilities. Basically, most of the researcher works on mathematical learning disabilities for the students of classes as primary, basic and secondary level. Author (Mazzocco et al., 2011), hypothesizes that mathematical learning disabilities partly results from a deficiency in the approximate number system that supports nonverbal numerical representations across species and throughout development. Author (Jitendra et al. 2020) investigated, taking sample of 338 students of seventh-grade with mathematical learning disabilities, based on scoring below 25th percentile on a proportional problem-solving pre-test. (Chu et al. 2019) Studied that in a preschool through first grade longitudinal study, author identified groups of children with persistently low mathematics achievement and children with low achievement in preschool but average achievement in first grade. Author (Reeve et al. 2019), presented a review on math learning difficulties in Australia. The article (Wu et al., 2019), proposed a study on mathematical learning disabilities in primary school children. In (Wu et al., 2019), author aims to conduct training to improve the brain's cognitive ability for mathematics learning by focusing on two important mathematical cognitive abilities. Author (Lewis, 2017), presented a case study of a student with a mathematical learning disability for whom standard instruction on fractions had been ineffective. The entire above cited masterwork, shows that most of the study on mathematical learning disability was focused on students of primary and secondary level. Our work reveals the problem of mathematical learning disability in higher education level. We observed a group of students at graduation level, who are not affected with mathematical learning disability but they are unable to comprehend the topic under abstract algebra, which is included in their syllabus. Our study shows that if we are unaware of student's present knowledge related to the topic then one might not be able to make them clear the concept interrelated to the subject. After taking a survey on different parameters, our observation sticks to the point for those students who require a remedial course work and also a conceptual based remedial lesson plan not only at secondary level but also at higher level classes. Such type of courses which are not focusing on the shortcomings of mathematical learning, in other terms it is not less than a motiveless -unplanned lecture. This study also represent that every frail mathematical learning student is not categorised in the case of mathematical learning disability. Our study also reveals that such type of survey is a necessity not only for higher classes but also for middle and secondary classes, before starting the syllabus.

Conclusion and Future Work

We conclude the paper on a speculative note. Before starting a lecture, new topic and syllabus in university level first the lecturer should take a glance on the points discussed in this paper. Surprisingly students are unaware about basic of abstract algebra even after being from mathematics surroundings, the state of students was found after completion of this survey, if this survey is not taken in consideration before delivering any lecture then it might not be a productive lecture for students. Therefore, it is necessary to create a remedial lesson plan for those students in order to assist them in right direction. Moreover, we presented a lecture plan with the help of theory, graphical and example-based approach on the topic dihedral group keeping in mind all the aspects discussed above. Finally, we have used an evaluation process to show the feasibility and validity of remedial lesson plan. In further, it is very much necessary to solve such problem of students at higher level, not only with a good remedial lesson plan but also with a durable remedial syllabus (course work). In addition, the aspects discussed can be considered to develop a questioner not only for one subject but for every subject so as to have a fruitful outcome at the end of the lecture.

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References

Goodchild, S. (2020). Book Review: The philosophy of mathematics education today. Paul Ernest. *Educational Studies in Mathematics*, *103*(1), 109-119.

Chen, C. L., & Wu, C. C. (2020). Students' behavioral intention to use and achievements in ICT-Integrated mathematics remedial instruction: Case study of a calculus course. *Computers & Education*, *145*, 103740.

Verschaffel, L., Schukajlow, S., Star, J., & Van Dooren, W. (2020). Word problems in mathematics education: a survey. *ZDM*, 1-16.

Erbilgin, E. (2019). Two mathematics teacher educators' efforts to improve teaching and learning processes: An action research study. *Teaching and Teacher Education*, *78*, 28-38.

Brijlall, D. (2020). Best Practices and Case Studies of Teaching and Learning Mathematics in Higher Education. In *Quality Management Implementation in Higher Education: Practices, Models, and Case Studies* 355-371.

Cohen, A. (2018). Attracting and Supporting Mathematicians for the Mathematical Education of Teachers. In *Mathematics Matters in Education* (pp. 259-275). Springer, Cham.

Novak, J., Kensington-Miller, B., & Evans, T. (2017). Flip or flop? Students' perspectives of a flipped lecture in mathematics. *International Journal of Mathematical Education in Science and Technology*, *48*(5), 647-658.

Wasserman, N. H. (2016). Abstract algebra for algebra teaching: Influencing school mathematics instruction. *Canadian Journal of Science, Mathematics and Technology Education*, *16*(1), 28-47.

Pimm, D. (2019). *Routledge Revivals: Speaking Mathematically (1987): Communication in Mathematics Clasrooms*. Routledge.

Johnson, E., Keller, R., & Fukawa-Connelly, T. (2018). Results from a survey of abstract algebra instructors across the United States: Understanding the choice to (not) lecture. *International Journal of Research in Undergraduate Mathematics Education*, *4*(2), 254-285.

Park, T., Woods, C. S., Hu, S., Bertrand Jones, T., & Tandberg, D. (2018). What happens to underprepared first-time-in-college students when developmental education is optional? The case of developmental math and intermediate algebra in the first semester. *The Journal of higher education*, *89*(3), 318-340.

Zengin, Y. (2019). Development of mathematical connection skills in a dynamic learning environment. *Education and Information Technologies*, *24*(3), 2175-2194.

Orcos, L., Arias, R., Magreñán, A., Sicilia, J. A., & Sarría, Í. (2019, April). Computer Application for the Evaluation of Mathematical Competence in Secondary Education: A Case Study. In *International Workshop on Learning Technology for Education in Cloud* (pp. 162-173). Springer, Cham.

Breen, S., & O'Shea, A. (2019). Designing Mathematical Thinking Tasks. *PRIMUS*, *29*(1), 9-20.

Sinan Schreglmann & Zekeriya Kazanc(2018). A Lesson Plan Development Study for Higher Education Based on Needs Assessment "Graphics and Animation in Education" Course. *International Education Studies, 11*(7),155-165.

Nuchanart Nesusin, et al. (2014). Development of Lesson Plans by the Lesson Study Approach for the 6th Grade Students in Social Study Subject based on Open Approach Innovation. *Procedia - Social and Behavioral Sciences, 116,* 1411-1415.

Marcia Devlin & Gayani Samarawickrema (2010) The criteria of effective teaching in a changing higher education context. *Higher Education Research & Development, 29*(2), 111-124, DOI: 10.1080/07294360903244398.

Saa, A. A., Al-Emran, M., & Shaalan, K. (2019). Factors affecting students' performance in higher education: a systematic review of predictive data mining techniques. *Technology, Knowledge and Learning*, *24*(4), 567-598.

Mazzocco, M. M., Feigenson, L., & Halberda, J. (2011). Impaired acuity of the approximate number system underlies mathematical learning disability (dyscalculia). *Child development*, *82*(4), 1224-1237.

Jitendra, A. K. (2020). Analysis of proportional reasoning and misconceptions among students with mathematical learning disabilities. *The Journal of Mathematical Behavior*, *57*, 100753.

Chu, F. W., Hoard, M. K., Nugent, L., Scofield, J. E., & Geary, D. C. (2019). Preschool deficits in cardinal knowledge and executive function contribute to longer-term mathematical learning disability. *Journal of experimental child psychology*, *188*, 104668.

Reeve, R. A. (2019). Mathematical Learning and Its Difficulties in Australia. In *International Handbook of Mathematical Learning Difficulties* (pp. 253-264). Springer, Cham.

Wu, T., Shen, H., Sheng, Y., Zhao, F., Guo, N., Liao, L., & Dong, X. (2019). Use of cognitive correction training improves learning for children with mathematics learning disability. *Applied Neuropsychology: Child*, 1-7.

Lewis, K. E. (2017). Designing a bridging discourse: re-mediation of a mathematical learning disability. *Journal of the Learning Sciences*, *26*(2), 320-365.

Joseph A Gallian (2010). *Contemporary Abstract Algebra* (8th Edition)., Cengage India, ISBN-9788131520741.

Making the Association between Culture and Mathematics Education

Nadide Yılmaz
Karamanoğlu Mehmetbey University

Culture and Mathematics

Mathematics was created by people to explain daily life and to help find solutions to problems that arise in social, cultural and natural environments (D'Ambrosio, 2001). In this process, as the interaction between people increased, mathematical knowledge between different cultures was affected by each other (D'Ambrosio, 1985). As a matter of fact, the existence of this interaction is noteworthy in the process of emergence of mathematical discoveries. For example, while the Maya invented the number zero and positional value attributed to Hindus in the 9th century (Rosa & Orey, 2005), these concepts were transferred from Hindus to Arabs through exchanges and commercial activities. Besides, the most well-known quantification is based on the Hindu-Arabic number system, which originates from a historical relationship between two different cultural groups that developed their own mathematical knowledge bases (Rosa & Gavarrete, 2017). As indicated in the examples, when the history of mathematics is examined, it is seen that mathematics is in direct interaction with culture, and that mathematics explored by different cultural groups has become valuable in this context (Nasir & Cobb, 2007, Rosa & Orey, 2011). People have developed mathematical concepts by passing through reasoning processes such as quantification and measurement on the basis of their cultural values and traditions in order to solve real life problems (Rosa & Orey 2010; Sunzuma & Maharaj, 2020). Researchers working on this subject point out the importance and necessity of addressing mathematics within the cultural context (Ascher, 2005; Küçük, 2013; Rosa & Orey, 2011).

While Bishop (1994) sees mathematics as a form of culture, Madusise (2015) states that mathematics is a subset of indigenous knowledge. This emphasis has shown itself in school mathematics as well, and it has been advocated that the process of learning-teaching mathematics should be structured in connection with culture (Bishop, Hart, Lerman, & Nunes, 1993; Seah & Bishop, 2003). Therefore, teaching mathematics cannot be separated from students' historical background, social context and world view (Gwekwerere, 2016) because learning becomes more meaningful when the teaching process is related to culture. Contextual learning environments related to culture make learning interesting and fun for children, especially in learning mathematics (Peni, 2019) because the learned mathematical concepts turn into activities that students can use in solving daily problems (Gravemeijer & Terwel, 2000). Mathematics teachers should pay attention to linking students' basic knowledge, cultures and histories with mathematics while structuring learning processes. The importance of this link should be emphasized in the training given to pre-service teachers who will be the teachers of the future, and it is emphasized that pre-service teachers should gain knowledge and skills about how to develop and integrate the relationship between culture and mathematics into learning environments (Harding-DeKam, 2007; Sharp, 1999; Supriadi, 2019). The inclusion of diverse ideas from people from different cultural contexts into the teaching-learning process allows students to see different perspectives in the process of learning mathematics (Rosa & Orey 2015). In addition, attention is drawn to the positive contribution of associating the mathematics learning process of students with low academic performance in mathematics with culture (D'Ambrosio, 2001). The benefits of this constant interaction between mathematics and culture paved the way for the emergence of the concept of ethnomathematics (D'Ambrosio, 2001; Fitroh & Himawati, 2015; Orey & Rosa, 2006).

Ethnomathematics

Although ethnomathematics began as "the study of the mathematical ideas of illiterate people" (Ascher & Ascher, 1986) in the 1980s, it has expanded into indigenous communities and cultures and a wide variety of professions (e.g. carpenters) over time (Barton, 2008; Costa & Silva, 2010; Knijnik, 1999; Masingila, 1994; Palhares, 2008; Shockey, 2002). According to Fitroh and Himawati (2015), ethnomathematics is culture-based or culture-influenced mathematics. When the etymology of ethnomathematics is examined, it is seen that "ethno" represents sociocultural contexts including language, jargon, symbols and behaviours, while "mathema" indicates activities such as measuring, classification, sequencing, interpretation, justification, understanding and knowing and "tics" comes from the same root as the words art and technique (D'Ambrosio, 1985). Ethnomathematics is defined as "the mathematics practiced by cultural groups, such as urban and rural communities, groups of workers, professional classes, children in a given age group, indigenous societies, and so many other groups that are identified by the objectives and traditions common to these groups." (D'Ambrosio, 2001, p.1). It is also a field of study that combines the history of mathematics, anthropology, pedagogy, linguistics and mathematics philosophy with a variety of pedagogical applications, as well as that focuses on explaining and understanding different sociocultural environments. It examines how different groups of people understand, express, process and use mathematical ideas, procedures and practices to solve problems related to their daily lives. In addition to presenting an innovative theoretical basis consisting of philosophical, political and epistemological dimensions of the development of mathematical knowledge, understanding human behaviour by making sense of the mathematical ideas and procedures applied by humanity can be described as another goal of ethnomathematics (D'Ambrosio, 1988, 1997; Rosa & Gavarrete, 2017). At this point, it can be said that ethnomathematics embraces mathematical ideas, thoughts, concepts and applications developed by different cultures as well as modern mathematics and science (Barton 1996; D'Ambrosio 1985; Frade, Acioly-Régnier, & Jun, 2013).

Ethnomathematics approach is based on social constructivism (Brandt & Chernoff, 2015; Laridon, Mosimege, & Mogari, 2005; Sunzuma & Maharaj, 2020) because in this research area, there is problem solving and situating learning in a real life context enriched with manipulative and interactive materials. In addition, it is aimed for individuals to discover new cultural experiences based on their previous experiences (Kurumeh, Onah, & Mohammed, 2012).

Ethnomathematics research has also focused on understanding the mathematical applications of different cultural groups and supporting the development of the world in a more just and equitable way by finding solutions to various problems (e.g. economic, environmental) (Bishop, 2004; D'Ambrosio, 2010; Wedege, 2010). Studies on the mathematics of different cultures reveal the need to investigate many components that affect this. For example, language is one of these components. Detailed examination of the language (e.g. grammar, signs) allows a deep understanding of the culture of that language (Meaney, Fairhall, & Trinick, 2008; Mosimege, 2017; Rosa & Gavarrete, 2017). Therefore, it is important for researchers to become familiar with local languages in order to access different forms of expression associated with the mathematical knowledge of other cultures (Mosimege, 2017; Rosa & Gavarrete, 2017). In addition to language, art and architecture, clothing types, food and tools that different cultural groups use to understand and explain their social, cultural and historical contexts embody the hidden mathematics (Alangui & Rosa 2016; Rosa, 2005; Rosa & Gavarrete, 2017; Rosa & Orey 2012). The mathematical concepts used in cultural works form part of the numerical relationships involved in measurement, calculation, games, divination, navigation, astronomy and modelling (Eglash, Bennett, O'Donnell, Jennings, & Cintorino, 2006).

Rosa and Orey (2015) argue that ethnomathematics is a body of knowledge built by members of different cultural groups over time and through generations in close contact with their historical, social, cultural and natural environment. It is pointed out that through ethnomathematics, mathematics will be understood as a social science that contributes to the sociocultural development of communities, the production and enrichment of knowledge, and the development of dialogue between academia and society. This approach fosters cultural autonomy and idiosyncrasy to promote respect for diversity, as it perceives mathematics as a social phenomenon and a human activity (Rosa & Gavarrete, 2017). This integrates mathematical practices that have historically been developed in different cultures (Massarwe, Verner, & Bshouty, 2010). It takes mathematics out of the institutional learning context such as schools and universities and places it in people's inner world, culture and daily activities (Bishop, 1994; Brandt & Chernoff, 2015).

Bishop (1991), one of the pioneering researchers in the field of ethnomathematics, focused on how different cultures make sense of mathematics and proposed specific activities and examined these activities by classifying them in the context of mathematics to make comparisons between cultures. These activities are expressed as counting, locating, measuring, designing, playing and explaining. Sub-activities including these activities are indicated in Table 1.

Table 1. Bishop's (1991) 6 Activities and Sub-Activities Done by Cultures

Counting	Locating	Measuring	Designing	Playing	Explaining
Quantifiers (each, some, many, none) Adjectival number names Finger and body counting Tallying Numbers Place value Zero Base 10 Operations on numbers Combinatorics Accuracy Approximation Errors Fractions Decimals Positives, Negatives Infinitely large, small Limit Number patterns Powers Number relationships Arrow diagrams Algebraic representation Events Probabilities Frequency representations	Prepositions Route descriptions Environmental locations Compass bearings Up/down Left/ right Forwards Backwards Journeys (distance) Straight and curved lines Angle as turning Rotations Systems of location: Polar coordinates 2D/3D coordinates Mapping Latitude/longitude Loci Linkages Circle Ellipse Vector Spiral	Comparative quantifiers (faster, thinner) Ordering Qualities Development of units (heavy heaviest- weight) Accuracy of units Estimation Length Area Volume Time Temperature Weight Conventional units Standard Units System of units (metric) Money Compound units	Design Abstraction Shape Form Aesthetics Objects compared by properties of form Large, small Similarity Congruence Properties of shapes Common geometric shapes, figures and solids Nets Surfaces Tesselations Symmetry Proportion Ratio Scale-model Enlargements Rigidity of shapes	Games Fun Puzzles Paradoxes Modelling Imagined reality Rule-bound activity Hypothetical reasoning Procedures Plans Strategies Cooperative games Competitive games Solitaire games Chance, prediction	Similarities Classifications Conventions Hierarchical classifying of objects Story explanations Logical connectives Linguistic explanations: Logical arguments Proofs Symbolic explanations: Equation Inequality Algorithm Function Figural explanations: Graphs Diagrams Charts Matrices Mathematical modelling Criteria: internal validity, external generalisability

While counting includes activities and sub-activities used to compare and sort out events, locating focuses on spatial relationships and aims to explore these relationships through various forms of representation (e.g. model, diagram, drawing). Measuring includes measuring by using measurement tools, starting from the purposes of comparison and sequencing. Designing includes visualizing a product/object. While playing includes developing and dealing with games and entertainment, explaining is about establishing relationships and making logical explanations based on the situations encountered.

Ethnomathematics and Mathematics Education

With the globalization in education as in everything else in the world, it has become clear that traditional mathematics education approaches need various revisions because the traditional mathematics education curriculum often ignores the contributions of members of colonized and non-dominant cultures to mathematics. This causes limited consideration of how different cultures contribute to various mathematical activities (e.g. comparison, measurement, inference) in school mathematics, in other words, ethnomathematics cannot find a place at the desired level in the curriculum (Peni, 2019; Rosa & Gavarrete, 2017). However, ethnomathematics can support better structuring of mathematics teaching as a bridge between culture and education (D'Ambrosio, 1989; Verner, Massarwe, & Bshouty, 2013; Widada, Sunardi, Herawaty, Boby, & Syefriani, 2018). Ernest's (2010) emphasis that mathematics is a cultural product allows the interpretation that this connection between mathematics and culture can be enriched through ethnomathematics in the process of teaching and learning mathematics (D'Ambrosio, 2001; Ernest, 2010) because ethnomathematics acknowledges that mathematical techniques, methods and explanations have been developed that allow different cultures to develop alternative understandings and social transformations to contribute to the process of achieving the targeted level of social justice, peace and respect (Rosa & Gavarrete, 2017). This contributes to the perception of school mathematics by students as "encouraging them to discover the mathematics of their own culture" (Gilmer, 1990).

Presence of mathematics in every field of life means that it is experienced by each culture and this makes its inclusion into the school mathematics curriculum compulsory (Brandt & Chernoff, 2015). In learning environments designed with an ethnomathematical approach, mathematical concepts are focused on through realistic activities and learning individuals are put into the centre (Mogari, 2014). Students can better understand the impact of culture on mathematics by valuing diversity in these types of math classrooms (Sunzuma & Maharaj, 2020). Using cultural contexts while structuring the teaching process supports students to see mathematics as a part of daily life, which helps them establish mathematical connections (La Ferla, Olkun, Gönülateş, & Alibeyoğlu, 2008). In addition, the use of works belonging to various cultures in teaching environments increases students' self-confidence and improves their creativity and encourages them to discover complex mathematical ideas and applications (D'Ambrosio 2006; Eglash, et. al., 2006; Orey 2000; Rosa & Orey 2015). Ethnomathematics has made significant contributions to learning and teaching of mathematics in traditional classrooms, especially to cultural roots, interactions between mathematics and languages, human interactions and values and beliefs (Bishop, 2002; 2010). However, it was noticed that ethnomathematics studies in learning environments were not at the desired level (D'Ambrosio, 2010a; Frade, et. al., 2013). The reasons for this are the high number of students' needs, the difficulty of creating teaching programs in the complexity of traditional classrooms, and anxiety about completing central exams and curriculum on time (D'Ambrosio, 2010b; Frade et al., 2013; Yolcu, 2019). However, one of the most important reasons for teaching mathematics is to make students aware that mathematics is an integral part of humanity's cultural heritage and that it should be seen as a reflection of the culture and thoughts of societies (D'Ambrosio, 1995). According to Adam, Alangui, and Barton (2003), a child's mathematics education first begins in the culture he/she lives in. With the progressing process, universal mathematics is encountered. At this point, the interaction of culture with mathematics can make important contributions to the development of mathematical thinking in children. As a matter of fact, the most creative, dynamic and productive societies take this emphasis into account in the educational and instructional process (Florida, 2004). For this reason, learning environments should be structured by considering the sociocultural contexts in line with the interests and needs of students, rather than just the application of procedures and formulas and curriculum activities free of context (Rosa & Gavarrete, 2017; Rosa & Orey, 2016; Vithal & Skovsmose, 1997).

Attention is drawn to the need to include cultural debates in mathematics curricula to help educators accept the relationship between cultural and school mathematics knowledge (Rosa & Gavarrete, 2016). If the process of teaching and learning mathematics is structured through cultural practices, students can gain the ability to relate the mathematics taught in the classroom to their natural environment (Sunzuma & Maharaj, 2020). The ethnomathematics approach covers all aspects of mathematics teaching and learning, consisting of the content and development of the curriculum to enhance teaching and learning (Aikpitanyi & Eraikhuemen, 2017). In addition, it is clear that ethnomathematics includes humanistic views such as respect for cultural diversity, equality and social justice and human rights in the classroom environment. Mathematics education researchers and teachers who agree with these views do not accept assumptions and claims based on the development of precise practices or any form of discrimination (Frade, et. al., 2013). The ethnomathematics perspective in mathematics education enables educators to rethink the nature of mathematics by seeing the perspectives of people from different cultures on mathematical ideas such as measurement, classification, regulation, inference, modelling (Rosa & Gavarrete, 2017).

Research shows that students who study with materials associated with ethnomathematics are more successful than those who do not and that their problem solving and critical thinking skills develop positively (Imswatama & Lukman, 2018; Supriadi, Suryadi, Sumarmo, Rakhmat, 2014). This reveals the importance of relating the materials to be used in the curriculum and teaching process to the culture (Peni, 2019). Other positive results were that students are more willing to be engaged in such activities and that they can evaluate mathematics from different perspectives (Meaney & Lange, 2013). Moreira (2007) suggests that a mathematics teacher should act as an ethnomathematics researcher. Rosa (2013) notes that it is important to understand both the culture and its connection with mathematics teaching, because teachers who are aware of this connection can design teaching practices to support the positive learning expectations of learners.

In general, it is thought that it is necessary to integrate ethnomathematics into every mathematics class because ethnomathematics supports students to develop their own understanding by making connections with what they have learned before. This also has the potential to help students feel accepted and be more accepting of others (Brandt & Chernoff, 2015). When the literature is reviewed, it can be said that the studies conducted are generally grouped under four headings. While some studies focus on how different cultures perceive various mathematical concepts, some others focus on the effects of students' working on activities prepared according to the ethnomathematical perspective. It is noteworthy that there are few studies involving the awareness, knowledge and skills of teachers and pre-service teachers about ethnomathematics. In some studies, both teachers and students are evaluated together (Figure 1).

Mathematics of different cultures	Teachers-pre-service teachers	Students	Teachers and students
• D'Ambrosio (2002) • Fantinato (2004) • Lipka & Andrew-Irhke, (2009) • Yusuf, Saidu & Halliru (2010) • Küçük (2014) • Aktekin (2017) • Pradhan (2017) • Septianawati, Turmudi & Puspita (2017) • Sharma & Orey (2017)	• Katsap & Silverman (2008) • Albanese & Gavarrete (2015) • Supriadi (2020) • Sunzuma & Maharaj (2020)	• Powell & Temple (2001) • Arismendi-Pardi (2001) • Magallanes (2003) • Lipka, Hogan, Webster, Yanez, Adams, Clark & Lacy (2005) • Achor, Imoko and Uloko (2009) • Kara (2009), • Kara & Togrol (2010) • Gerdes (2011) • Kurumeh, et. al. (2012) • Aktuna (2013) • Kørhsen & Misfeldt (2015) • Amit & Abu Qouder (2017) • Imswatama & Lukman (2018) • Widada, Herawaty, Falaq, Anggoro, Yudha & Hayati (2019)	• Adam (2004) • Massarwe, Verner & Bshouty(2012) • Shuaibu (2014)

Figure 1. Classification of Studies on Ethnomathematics

It has been revealed that studies focusing on the mathematics of different cultures look at how they handle mathematics in tools such as languages, games, architectural works, agricultural tools, musical instruments used by cultures. Although studies emphasize many points, the common result that they all draw attention to is that there is mathematics in every tool used by cultures (Aktekin, 2017; D'Ambrosio, 2002; Fantinato, 2004; Küçük, 2014; Lipka & Andrew-Irhke, 2009; Pradhan, 2017; Septianawati, et. al., 2017; Sharma & Orey, 2017; Yusuf, et. al., 2010). These studies are presented below in detail.

D'Ambrosio (2002) focused on the relationship of wines brought to Southern Brazil by Italian immigrants with mathematics. Interviews were made with winemakers, and it was noticed that winemakers who made their own barrels found their barrel volume through a process very different from academic mathematics. It is stated that this application is a very good reflection of ethnomathematics because the producer learned the wine-making techniques from his/her father long before he/she came to Brazil, and these techniques have been handed down from generation to generation for centuries.

Fantinato (2004) shared the results of an ethnomathematics study conducted on a group of low-educated adults living in a poor neighbourhood of Rio de Janeiro. The study aimed to understand the quantitative and spatial representations created and used in different life contexts and the relationships between these representations and school mathematics knowledge. The data obtained show that there is a strong relationship between the use of mathematical skills in daily life and survival strategies to meet basic needs such as managing a reduced budget. In addition, it has been observed that mathematics is also associated with emotional factors such as protecting one's identity. In addition, this study clarified the prevalence of social and economic factors that interfere with the creation, representation and use of mathematical knowledge in the urban context.

Lipka and Andrew-Irhke (2009) focused on how mathematics is culturally handled and carried out their study in Alaska. They brought mathematicians, mathematics educators, education researchers, teachers and adult people from the Yupik people of Alaska together and examined the mathematical knowledge that the Yupik people used in the process of producing parquets, which they called Yupik. In this process, it was concluded that the method used by one of the students to create the square, which is a geometric shape, included the use of the hand finger joint as the unit of length measurement, has a proof beyond the Euclidean geometry, that the student found the middle point of the square by folding this square into one-quarter to form smaller squares and used the transformation geometry while doing these.

Yusuf, et. al. (2010) examined the relationship between mathematics and the games played by people in the Hausa community living in Western Nigeria. In the study, it was determined that these games were shaped by the stories told and questions asked by the adults of the culture in order for children and young people in the Hausa culture to develop their thinking powers and minds and to learn lessons for them. As a result of the study, it was revealed that the games played in Hausa culture are related to important mathematical subjects such as algebra, set theory, trigonometry, coordinate plane, arithmetic and geometric sequences, sorting, classification, measurement, timing and weighing. However, in the interviews made with the participants at the beginning of the study, it was noted that they stated that they thought that they did not have mathematics in their culture and that they did not have any connections with mathematics other than the lessons given at school.

Küçük (2014) linked the architectural and engineering structures in Anatolian culture and the carpet and rug motifs created in this culture with geometry. The findings have shown that bridges built in Anatolian culture in previous centuries have paraboloid surfaces to ensure that they are resistant to natural disasters and to minimize the amount of oscillation they will make in the face of possible effects. In addition, it was observed that the fountains in Anatolian culture were built with a paraboloid surface in order to easily drink water.

Aktekin (2017) compiled 86 different cultural elements, which he chose from Anatolian culture, under a total of six headings: number systems, measurement units, architecture and engineering, art, mind games and agriculture, and analyzed them in an ethnomathematical sense. The results obtained showed that the practices people have performed within the scope of their culture are directly related to the mathematical thoughts they have. This shows the relationship between mathematics and culture and the importance of ethnomathematics in this relationship.

Pradhan (2017) aimed to reveal the mathematical knowledge used in the production of wooden works owned by Chundara, one of the professional caste groups in Nepal. To this end, he conducted in-depth interviews and observed activities at the Chundara workplace. The teaching and learning activities of Chundara took place in a participatory and collaborative way with the help of more experienced people. It was revealed that mathematics was used while making wooden works.

Sharma and Orey (2017) focused on how dhol, a musical instrument made and played by members of the Rai cultural group in Nepal, can be made meaningful for students. The researchers discussed how the use of culturally contextualized mathematics in this musical instrument can help students explore the relationship between school mathematics and their culture.

Septianawati, et. al. (2017) conducted a study to determine the specific length, area and volume units used by the Kampung Naga community, a traditional community living in Indonesia and separated from other cultures with their unique lifestyles, and the equivalents of these units in the standard units. They revealed that the lengths were measured by a rope, one knot was tied on each unit on the rope where the length was measured, and the number of knots obtained gave the measure of the length to be measured. Another finding is that community-specific length measurement units are called jeungkal, deupa or sameter. Area measurement calculations are made by measuring the edges of the area to be measured in meters, and then transforming them into bata (tumbak), areu and bau units, which are their unique area measurement units. Volume measurements are mainly used in house construction. Since the houses are mostly made of wood, the volume of the wood to be used for parts such as columns and beams in the house is calculated by multiplying the length, width and thickness values of the wood. Élo, dim, strip and kibik are used as the units of volume measurement.

It can be said that studies conducted with pre-service teachers and teachers are relatively fewer. From among these few studies, the majority were conducted with pre-service teachers (Albanese & Gavarrete, 2015; Katsap & Silverman, 2008; Supriadi, 2020) and the number of such studies conducted on teachers is highly limited (Sunzuma & Maharaj, 2020). The results obtained revealed that ethnomathematics applications conducted with pre-service teachers had positive effects in various respects (Albanese & Gavarrete, 2015; Katsap & Silverman, 2008; Supriadi, 2020). Another remarkable finding is that teachers have awareness of the application of ethnomatics (Sunzuma & Maharaj, 2020). These studies are given below in more detail.

Katsap and Silverman (2008) researched the naturally occurring mathematics in the cultures of Jewish and Bedouin peoples, developed projects based on their discoveries and shared them in the classroom. In this process, the pre-service teachers shared their lesson plans and classroom activities in the classroom environment as well as the ethnomathematics activities obtained directly from their cultural experiences. The results obtained enabled the pre-service teachers to learn about their own culture and to start perceiving mathematical concepts as a mixture of two different understandings (academic mathematics and mathematics in the understanding of cultures).

Albanese and Gavarrete (2015) discussed two experiences in teacher education. Both of these experiences are based on ethnomathematics. The focus was on the way a group of folk dancers from Argentina and an indigenous people from Costa Rica construct geometric figures. Both of the experiences were observed to affect teacher education. In this way, it was emphasized that the reflection of mathematical knowledge and teaching practices in the curriculum in connection with the sociocultural environment fosters the creativity of pre-service teachers.

Supriadi (2020) collected the opinions of pre-service primary school teachers who were grouped on the basis of their educational background (science or non-science) and Sundanese language ability background (Sundanese language and non-Sundanese language) through questionnaires. The results revealed that the learning of ethnomathematics positively affected most of their tendency towards mathematical modelling.

Sunzuma and Maharaj (2020) aimed to understand teachers' awareness of ethnomathematics approaches and the applications of ethnomathematics that can be used in teaching and learning geometry. Data were collected through questionnaires and focus-group discussions. The findings showed that in-service teachers have different definitions of ethnomathematics approaches and are aware of the ethnogeometric practices found in their cultural practices and experiences that can be integrated into geometry teaching and learning.

It can be said that ethnomathematics studies have been mainly carried out on students. (Achor, et. al., 2009; Aktuna, 2013; Amit & Abu Qouder, 2017; Arismendi-Pardi, 2001; Gerdes, 2011; Imswatama & Lukman, 2018; Kara, 2009; Kørhsen & Misfeldt, 2015; Kurumeh, et. al., 2012; Lipka, et. al., 2005; Magallanes, 2003; Powell & Temple, 2001; Widada et. al., 2019). The results obtained, except for one study (Kara & Togrol, 2010), revealed that learning environments associated with ethnomathematics support the development of students in the following aspects.

- Make them realize that mathematics is more than numbers and formulas,

- Foster their achievement in academic mathematics,
- Make them individuals who can solve problems better and improve their critical thinking skills,
- Help them discover cultural thoughts such as self-control, competition, respect to other people, cooperation,
- Reveal the relationship between academic mathematics and cultural mathematics,
- Make them discover the existence of mathematics in tools such as games, architectural works, agriculture and language as well as professional and daily activities,
- Support the development of positive attitudes and self-confidence towards mathematics.

These studies are given in more detail below.

Powell and Temple (2001) investigated the process of playing a strategy game played on a board with pits on the board called Oware in Africa, known by different names in many cultures and played according to different rules adopted in different cultures by African American and Latin children living in America in both mathematical and cultural respects. In this process, it was observed that mathematical ideas such as inequality, estimation, number patterns emerged, as well as cultural ideas such as self-control, competition, respect for other people and cooperation.

Arismendi-Pardi (2001) compared the final exams of students who had been taught algebra with an ethnomathematical approach and those who had not. The results obtained showed that the students whose lessons were structured with the ethnomathematical approach were more successful than the students whose lessons were not structured with an ethnomathematical approach.

Magallanes (2003) focused on the subject of coordinate plane in his quasi-experimental study conducted on the students attending Torch Middle School in California. While the experimental group students were taught with activities associated with ethnomathematics, the control group students were taught with the traditional method. The results obtained showed that the experimental group students' achievement scores are significantly higher than those of the control group students. A very similar study was carried out with 248 Junior Secondary three students in Obi and Oju education areas of zone C in Benue state of Nigeria by Kurumeh, et. al. (2012) and similar results were obtained.

Lipka, et. al. (2005) conducted an application with the participation of local Yupik elders, teachers, schools and communities, and then an experimental study was conducted to observe students' mathematical performance and changes after the application. The activities prepared focused on integrating daily knowledge into school mathematics. The findings revealed that the students discovered mathematical concepts in more depth while engaged in the activities. In addition, this teaching experiment that students participated in caused statistically significant differences in terms of improving their academic math performance. In addition, these activities were observed to support students in establishing the relationship between real life situations and mathematics.

Achor, et. al. (2009) conducted a quasi-experimental study with 253 students by designing learning environments with an ethnomathematical approach in Nigeria. The subject focused on in the study was the concept of trajectory in geometry and the experimental group students were thought with ethnomathematical approach and the control group students with the traditional approach. The results showed that the mean achievement score of the students taught with the ethnomathematical approach was approximately twice more than the score of those who were taught with the traditional approach. In addition, it was found that the mean retention score of the students taught with the ethnomathematical approach were approximately three times more than the score of those who were taught with the traditional approach.

Kara (2009) focused on students' achievements in and attitudes towards mathematics with a semi-experimental study. Lessons were designed in experimental groups with an ethnomathematical approach. A total of 137 middle school 7th grade students were included in the study, focusing on symmetry, pattern and the features of the structures in Topkapı Palace. The results revealed that while the mathematics achievement scores of the experimental and control groups of the participants in two of the three different middle schools are close to each other, there is a significant difference between the mathematics achievement scores of the experimental and control group students from the third school. In addition, although no significant difference was found between the attitude scores of the students from two middle schools, a statistically significant difference was found between the attitude scores of the experimental and control groups from the third school.

Gerdes (2011) used African Art to teach various concepts of geometry (e.g. area and circumference of the circle, symmetry and transformation), using handbag, hat, straw and basket tray decorations in Mozambique. Gerdes (2011) advocated their use in geometry teaching and learning in primary school settings. It was emphasized that the artistic ornaments in the works could be used while structuring the geometry learning-teaching process and that geometric concepts could be structured based on these ornaments. It was also pointed out that with the works used, geometry can become concrete for students.

Aktuna (2013) conducted a study with the children of families living in rural areas and earning their livelihood mostly with olives and a total of 12 6th graders participated in the study. With the help of their cultures and real life situations, ethnomathematics activities were designed for the participants, and the students' perceptions and associations in relation to the measurement of an area were examined. The findings revealed that the mathematics performance of the students with medium and below-medium mathematics achievement increased significantly, while the mathematics performance of the students with high and low mathematics achievement did not change. In addition, the students' interest, self-confidence and motivation in mathematics increased, and a more peaceful and collaborative classroom environment was created.

Kørhsen and Misfeldt (2015) stated that Minecraft, a digital game, allows students to create their own worlds and try to survive in this world by encouraging them to use their creative thinking and imagination. Thus, it was stated that this game could be used in mathematics education and 7 students at the age of 10 were asked to play this game after school. The methods and strategies they followed while playing this game, the problems they encountered and the information they used to solve these problems and the solution processes they followed were examined by adopting an ethnomathematical perspective and ethnographic research method. The findings obtained showed that while playing this game, students performed all six basic activities that Bishop (1991) put forth.

Amit and Abu Qouder (2017) aimed to integrate ethnomathematics into the mathematics curriculum of Bedouin students and overcome the difficulties in the mathematical structures of their daily lives and traditional length and weight units. First of all, 35 Bedouin adults were interviewed and then, based on the data obtained from these interviews, a 30-hour 7th grade unit was integrated into the ethnomathematical approach in two Bedouin schools. Experimental and control groups were constructed and then the unit was taught. The findings revealed that the experimental group students' self-perception and motivation improved. However, the results of the test administered immediately after the completion of the study showed that there is no significant difference between the achievements of the experimental and control groups. The study caused students to raise their awareness by changing their attitudes towards their own culture and the older generation of the tribe.

Imswatama and Lukman (2018) examined the effect of teaching materials prepared with an ethnomathematical perspective on mathematical problem solving skills and critical thinking of students. Only the posttest control design was used in the study. The results revealed that the mathematics teaching materials based on ethnomathematics was effective in developing problem solving skills and mathematical critical thinking of students. In addition, it was concluded that the materials used with an ethnomathematical perspective fostered students' effectiveness.

Widada, et. al. (2019) used pretest-posttest group design to examine how students' ethnomathematics-based approach affects problem solving. The study conducted on high school students revealed that students are better problem solvers in problem solving environments integrated into ethnomathematics.

Kara and Togrol (2010) designed a teaching to which 6-hour ethnomathematics was integrated focusing on the subject of symmetry, reflection, and decorations in the 7th grade. Experimental and control groups were constructed and the designed teaching was conducted with the experimental group. The results revealed that there is no significant difference between the achievement scores of the experimental and control groups. With the results it presented, the current study is different from other studies.

In some studies, teachers and students were included as participants together (Adam, 2004; Massarwe, et. al., 2012; Shuaibu, 2014). The findings revealed that including ethnomathematics in the teaching process helped both teachers and students to be aware of the relationship between academic mathematics and cultural mathematics. These studies are given below in more detail.

Adam (2004) structured the application he carried out with 5th grade teachers and students in the Maldives with an ethnomathematical perspective. The study focused on the concepts of environment, area and volume. Teachers and students went to different places such as markets, carpentry and boat building sheds to explore the features of these concepts in more depth. It was noted in this process that both teachers and students were able to get to know cultural activities and experiences that exhibit measurement systems in Maldivian culture. They were able to establish the relationship between the cultural mathematics activities they had learned and school mathematics. It was also found that the students were satisfied with the integration of ethnomatics into this process.

Massarwe, et. al. (2012) prepared a project that would support middle school students and teachers to make connections between geometry and culture by involving them in well-established ethnomathematics activities in their own and other cultures. The results showed that the participants were not aware of the relationship between geometry and culture at the beginning of the process. After the project, it was observed that they developed a great deal of awareness about the relationship between geometry and culture.

Shuaibu (2014) aimed to determine the mathematical thinking levels of students studying in two different states of Nigeria (rural and urban) and examined the effects of their cultures on the development of students' mathematical thinking levels. The participants of the study were all the students attending secondary schools in Kano and Oyo states and their mathematics teachers. Different questionnaires were applied to teachers and students during the research process. The results showed that there is no significant difference between the mathematical thinking levels of the middle school students, that there are activities to develop mathematical thinking of the students in both of the cultures and that the students living in the rural area have a higher level of mathematical thinking than the students living in the urban area.

Concluding Remarks

Although studies have revealed the contributions of ethnomathematical research to both mathematics and mathematics education, some researchers, philosophers and educators state that they have some doubts about the role of ethnomathematics in mathematics education (Rosa & Gavarrete, 2017). "Which culture(s) should be in the mathematics curriculum? How would we know whether or not the educators and students make the link between culture and mathematics? How can an ethnomathematical attitude help develop a critical and reflective understanding of the mathematics curriculum? (Rosa & Gavarrete, 2017 p.14)" and similar questions are waiting to be answered in the field of ethnomathematics. This indicates that there is a need for more research.

References

Achor, E. E., Imoko, B. I., & Uloko, S. E. (2009). Effect of ethnomathematics teaching approach on senior secondary students' achievement and retention in Locus. *Educational Research and Review, 4*(8), 385-390.

Adam, S. (2004). Ethnomathematical ideas in the curriculum. *Mathematics Education Research Journal*, *16*(2), 49–68.

Adam, S., Alangui, W., & Barton, B. A. (2003). Comment on Rowlands and Carson: "Where would formal academic mathematics stand in a curriculum informed by ethnomathematics? A critical reviw", *Educational Studies in Mathematics, 52*(3), 327-335.

Aikpitanyi, L. A., & Eraikhuemen, L. (2017). Mathematics teachers' use of ethnomathematics approach in mathematics teaching in Edo State. *Journal of Education and Practice*, *8*(4), 34–38.

Alangui, W. V., & Rosa, M. (2016). Role of ethnomathematics in mathematics education. In M. Rosa, U. D'Ambrosio, D. C. Orey, L. Shirley, W. V. Alangui, P. Palhares, & M. E. Gavarrete (Eds.), *Current and future perspectives of ethnomathematics as a program* (pp. 31–37). ICME13 Topical Surveys. London, England: Springer Open.

Aktekin, D. (2017). *Etnomatematik*. (Unpublished master thesis). Kocaeli Üniversitesi, Kocaeli.

Aktuna, H. E. (2013). *Sixth grade students' perceptions of and engagement in* *ethnomathematical tasks in the area measurement concept*. (Unpublished master thesis) Middle East Technical University, Ankara.

Albanese, V. & Gavarrete, M. E. (2015). Teacher training through research in ethnomathematics. CERME 9 - *Ninth Congress of the European Society for Research in Mathematics Education* (pp.1665-1666). Prague, Czech Republic, Feb 2015.

Amit, M., & Abu Qouder, F. (2017). Weaving culture and mathematics in the classroom: the case of bedouin ethnomathematics. In Rosa, M., Shirley, L., Gavarrete, M., & Alangui, W. (Eds.). *Ethnomathematics and its Diverse Approaches for Mathematics Education* (pp. 23-50). ICME-13 Monographs. Springer, Cham.

Arismendi-Pardi, E. J. (2001). *Comparison of the final grades of students in intermediate algebra taught with and without an ethnomathematical pedagogy. The global perspective: Teaching, learning and student equity.* A presentation to the Center for the Study of Diversity in Teaching and Learning in Higher Education. Miami, Florida.

Ascher, M. (2005). *Etnomatematik: Matematik Dünyasına Çok Kültürlü Bir Bakış* (Çeviri: Ercan, B.), İstanbul: Okyanus Yayıncılık.

Ascher, M., & Ascher, R. (1986). Ethnomathematics. *History of Science, 14*, 125–144.

Barton, B. (1996). Making sense of ethnomathematics: Ethnomathematics is making sense. *Educational Studies in Mathematics, 31*(1–2), 201–233.

Barton, B. (2008). *The languages of mathematics*. New York, NY: Springer.

Bishop, A. J. (1991). *Mathematical enculturation: perspective on mathematics education*. Netherlands: Kluwer Academic Publishers.

Bishop, A. J. (1994). Cultural conflicts in mathematics education: Developing a research agenda. *For the Learning of Mathematics, 14*(2), 15–18.

Bishop, A. (2002). Mathematical acculturation, cultural conflicts, and transition. In G. De Abreu, A. J. Bishop, & N. C. Presmeg (Eds.), *Transitions between contexts of mathematical practices* (pp. 193–212). Dordrecht, The Netherlands: Kluwer Academic Publishers.

Bishop, A. J. (2004, July). *Critical issues in researching cultural aspects of mathematics education*. Paper presented in Discussion Group 2, 10th International Congress on Mathematics Education, Copenhagen, Denmark. Retrieved from http://www.icme-organisers.dk/dg02/

Bishop, A. (2010). Directions and possibilities for research on mathematics and culture, in relation to mathematics education: A personal view. In M. M. F. Pinto & T. F. Kawasaki (Eds.), *Proceedings of the 34th Conference of the International Group for the Psychology of Mathematics Education* (Vol. 1, pp. 338–342). Belo Horizonte, Brazil: PME.

Bishop, A., J.; Hart, K., Lerman, S. & Nunes, T. (1993). Significant Influences On Children's learning of mathematics, *Science and Technology Education, 47,* 3-61.

Brandt, A., & Chernoff, E. J. (2015). The importance of ethnomathematics in the math class. *The Ohio Journal of School Mathematics*, *71*, 31–36.

Costa, W. G., & Silva, V. L. (2010). A desconstrução das narrativas e a reconstrução do currículo: a inclusão dos saberes matemáticos dos negros e dos índios brasileiros (Narrative deconstruction and curriculum reconstruction: The inclusion of Brazilian indians' and black people's mathematical knowledge). *Educar, 36*, 245–260.

D'Ambrosio, U. (1985). Ethnomathematics and its place in the history and pedagogy of mathematics. *For the Learning of Mathematics, 5*(1), 44–48.

D'Ambrosio, U. (1988). A research program in the history of ideas and in cognition. *International Study Group on Ethnomathematics (ISGEm) Newsletter*, *4*(1), 5-8.

D'Ambrosio, U. (1989). A research program and a course in the history of mathematics: Ethnomathematics, *Historia Mathematica, 16*, 285–288.

D'Ambrosio, U. (1995). Multiculturalism and mathematics education. *International Journal on Mathematics Science, and Technology Education, 26*(3), 337–346.

D'Ambrosio, U. (2001).What is ethnomathematics and how can it help children in schools? *Teaching Children Mathematics*, *7*(6), 308–310.

D' Ambrosio, U. (2002). *Teaching and learning with mathematical modeling*. São Paulo: Editora Contexto.

D'Ambrosio, U. (2006). *Ethnomathematics: Link between traditions and modernity.* Roterdam, The Netherlands: Sense Publishers.

D'Ambrosio, U. (2010a). Ethnomathematics: A response to the changing role of mathematics in society. *Philosophy of Mathematics Education Journal. Special issue on Critical Mathematics Education, Vol, 25.*

D'Ambrosio, U. (2001). What is ethnomathematics, and how can it help children in schools?. *Teaching children mathematics, 7*(6), 308-308. Retrieved from http://vello.sites.uol.com.br/what.htm .

Eglash, R., Bennett, A., O'Donnell, C., Jennings, S., & Cintorino, M. (2006). Culturally situated designed tools: Ethnocomputing from field site to classroom. *American Anthropologist, 108*(2), 347–362.

Ernest, P. (2010). Add it up: Why teach mathematics? *Professional Educator*, *9*(2), 44–47.

Fantinato, M. C. C. B. (2004). Contribuiçoes da etnomatematica na educaçao de jovens e adultos: algumas reflexoes iniciais. In. J. P. M. Ribeiro, M. C. S. Domite, & R. Ferrira, (Eds.) *Etnomatematica: papel, valor e significado* (pp. 171-184). Sao Paulo: Zouk.

Florida, R. (2004). *The rise of the creative class and how it is transforming work, leisure, community and everyday life*. New York, NY: Basic Books

Fitroh W & Himawati N. (2015). Identifikasi Pembelajaran Matematika dalam Tradisi Melemang di Kabupaten Kerinci Provinsi Jambi. *Prosiding Seminar Nasional Matematika dan Pendidikan matematika UMS 2015.*

Frade, C., Acioly-Régnier, N., & Jun, L. (2013). Beyond deficit models of learning mathematics: Socio-cultural directions for change and research. In M. A. K. Clements, A. Bishop, C. Keitel-Kreidt, J. Kilpatrick, & F. K.-S. Leung (Eds.), *Third international handbook of mathematics education* (pp. 101–144). New York, NY: Springer.

Gerdes, P. (2011). African basketry: Interweaving art and mathematics in Mozambique. In *Bridges Coimbra mathematics, music, art, architecture, culture conference proceedings* (pp. 9–16). Coimbra: Tessellations Publishing.

Gilmer, G. (1990). An ethnomath approach to curriculum development. *ISGEm Newsletter*, *5*(2), 4–5.

Gwekwerere, Y. (2016). Schooling and the African child: Bridging African epistemology and eurocentric physical sciences. In E. Shizha & G. Emeagwali (Eds.), *African indigenous knowledge and the sciences. Journeys into the past and present: Anti-colonial educational perspectives* (pp. 33–46). Rotterdam: SensePublishers.

Gravemeijer, K., & Terwel, J. (2000). Hans Freudenthal: a mathematician on didactics and curriculum theory. *Journal of curriculum studies, 32*(6), 777-796.

Harding-DeKam, J. L. (2007). Foundations in ethnomathematics for prospective elementary teachers. *Journal of Mathematics and Culture, 1*(2).

Imswatama, A & Lukman, H., S. (2018). The Effectiveness of Mathematics Teaching Material Based on Ethnomathematics. *International Journal of Trends in*

Mathematics Education Research, 1(1), 35-38.

Kara, M. (2009). *Effects of instructional design integrated with ethnomathematics: Attitudes and achievement.* (Unpublished master thesis). Boğaziçi University, İstanbul.

Kara, M., & Togrol, A. Y. (2010). Effects of instructional design integrated with ethnomathematics: Attitudes and achievement. In K. Gomez, L. Lyons, & J. Radinsky, (Eds.), *Learning in the Disciplines: Proceedings of the 9th International Conference of the Learning Sciences,* (Vol.1, pp. 730-735). Chicago, IL: International Society of the Learning Sciences.

Katsap, A. & Silverman, F. L. R. (2008). A case study of the role of ethnomathematics among teacher education students from highly diverse cultural backgrounds, *J. Math. Cult. 3*, 66-102.

Kørhsen, K. L., & Misfeldt, M. (2015). An ethnomathematical study of play in minecraft. *Nordic research in mathematics education: Norma, 14*, 205-214.Retrieved from https://helda.helsinki.fi/handle/10138/159388

Kurumeh, M. S., Onah, F. O., & Mohammed, A. S. (2012). Improving students' retention in junior secondary school statistics using ethno-mathematics teaching approach in Obi and Oju local government area of Benue State, Nigeria. *Greener Journal of Educational Research*, *2*(3), 54–62.

Küçük, A. (2014). Ethnomathematics in Anatolia-Turkey: Mathematical Thoughts in Multiculturalism. *Revista Latinoamericana de Etnomatemática, 7*(1), 171-184.

Knijnik, G. (1999). Ethnomathematics and the Brazilian landless people education. *Zentralblatt fur Didaktik der Mathematik, 31* (3), 188–194.

La Ferla, V. Olkun, S. Gönülateş, F. & Alibeyoğlu, M., A. (2008). *Multicultural look at mathematics*, 11th International Congress on Mathematical Education, Monterrey, Mexico, 6-13 July 2008.

Laridon, P. E. L., Mosimege, M., & Mogari, D. (2005). Ethnomathematics in developmental curriculum research in South Africa. In C. Keitel, R. Vithal, & J. Adler (Eds.), *Handbook of research in mathematics education in South Africa* (pp. 133–160). HSRC Press.

Lipka, J., & Andrew-Ihrke, D. (2009). Ethnomathematics applied to classrooms in Alaska: Math in a cultural context. *NASGEm Newsletter*, *3*(1), 8-10.

Lipka, J., Hogan, M. P., Webster, J. P., Yanez, E., Adams, B., Clark, S., & Lacy, D.

(2005). Math in a cultural context: Two case studies of a successful culturally based math project. *Anthropology and Education Quarterly, 36(*4), 367-385.

Madusise, S. (2015). Cultural villages as contexts for mediating culture and mathematics education in the South African curriculum. *Revista Latinoamericana de Etnomatemática*, *8*(2), 11–31.

Magallanes, A.M. (2003). *Comparison of student test score in a coordinate plane unit using traditional classroom techniques versus traditional techniques coupled with an Ethnomathematics software at torch middle school.* Retrieved from ERIC database. (ED479958).

Masingila, J. O. (1994). Mathematics practice in carpet laying. *Anthropology & Education Quarterly, 25*(4), 430–462.

Massarwe, K., Verner, I., & Bshouty, D. (2010). An ethnomathematics exercise in analysing and constructing ornaments in a geometry class. *Journal of Mathematics and Culture, 5*(1), 1-20 .

Massarwe, K., Verner, I., & Bshouty, D. (2012). Ethnomathematics and multicultural education: Analysis and construction of geometric ornaments. *Journal of Mathematics and Culture*, *6*(1), 344–360.

Meaney, T., Fairhall, U., & Trinick, T. (2008). The role of language in ethnomathematics. *The Journal of Mathematics and Culture, 3*(1), 52–65.

Meaney, T. & Lange T. (2013). Learners in Transition Between Contexts. In M. A. K. Clements, A. Bishop, C. Keitel-Kreidt, J. Kilpatrick, & F. K.-S. Leung (Eds.), *Third international handbook of mathematics education* (pp. 169-201). New York, NY: Springer.

Mosimege, M. (2017). Listening to the Voices of the Knowledge Holders: The Role of Language in Ethnomathematical Research, In: Rosa M., Shirley L., Gavarrete M., Alangui W. (eds) *Ethnomathematics and its Diverse Approaches for Mathematics Education* (pp.51-68). ICME-13 Monographs. Springer, Cham.

Mogari, D. (2014). An in-service programme for introducing an ethnomathematical approach to mathematics teachers. *Africa Education Review*, *11*(3), 348–364.

Moreira, D. (2007). Filling the gap between global and local mathematics. In D. Pitta-Pantazi & G. Philippou (Eds.), *Proceedings of the Fifth Congress of the European Society for Research in Mathematics Education 22 – 26 February 2007, Larnaca, Cyprus,* (pp. 1587–1596). European Society for Research in Mathematics Education & Department of Education, University of Cyprus.

Nasir, N. S. & Cobb, P. (2007). *Equity In Students' Access to Significant Mathematical Ideas*, NY: Teachers College Press, New York.

Orey, D. C. (2000). The ethnomathematics of the Sioux tipi and cone. In H. Selin (Eds.), *Mathematics across culture: The history of non-western mathematics* (pp. 239–252). Dordrecht, The Netherlands: Kluwer Academic Publishers.

Orey, D. C., & Rosa, M. (2006). Ethnomathematics: Cultural assertions and challenges towards pedagogical action. *The journal of Mathematics and Culture, 1*(1), 57-78.

Powell, A. B., & Frankenstein, M. (Eds.). (1997). *Ethnomathematics: Challenging Eurocentrism in mathematics education* (pp. 15-21). New York: SUNY Press

Palhares, P. (Ed.). (2008). *Etnomatemática—Um olhar sobre a diversidade cultural e a aprendizagem matemática [Ethnomathematics—A look at the cultural diversity and the mathematics learning]* . Vila Nova de Famalicão: Húmus.

Pradhan J. B. (2017) Mathematical Ideas in Chundara Culture: Unfolding a Nepalese Teaching and Learning System. In: Rosa M., Shirley L., Gavarrete M., Alangui W. (Eds.) *Ethnomathematics and its Diverse Approaches for Mathematics Education.* (pp.125-152). ICME-13 Monographs. Springer, Cham.

Peni, N.R. (2019). Development Framework of Ethnomathematics Curriculum through Realistic Mathematics Education Approach. *IOSR Journal of Research & Method in Education (IOSR-JRME), 9*(4), 16-24.

Powell, A. B., & Temple, O. L. (2001). Seeding ethnomathematics with oware: Sankofa. *Teaching children mathematics, 7*(6), 369-373.

Rosa, M. (2005). *The ethnomathematics of Bakairi Body Painting.* In NCTM Annual Meeting and Exposition: Embracing Mathematical Diversity. Anaheim, CA: NCTM.

Rosa, M. (2013). Accessing the perceptions of high school teachers about the influence of language and culture in thematics learning of English language learners (ELLs) students. *Linguistics, Culture & Education*, *2*(1), 36–71.

Rosa, M., & Gavarrete, M. E. (2016). Polysemic interactions between ethnomathematics and culturally relevant pedagogy. In M. Rosa, U. D'Ambrosio, D. C. Orey, L. Shirley, W. V. Alangui, P. Palhares, & M. E. Gavarrete (Eds.). *Current and future perspectives of ethnomathematics as a program* (pp. 23–30). ICME13 Topical Surveys. London, England: Springer Open.

Rosa, M. & Gavarrete, M. E. (2017). An Ethnomathematics Overview: An Introduction, In M. Rosa, L. Shirley, M. E. Gavarrete, W. V. Alangui (Eds.) *Ethnomathematics and its diverse Approaches for Mathematics Education* (pp. 3-19), ICME13 Monographs. London, England: Springer Open.

Rosa, M., & Orey, D. C. (2005). Las raízes históricas del programa etnomatemáticas [Historical roots of the ethnomathematics program]. *RELIME, 8*(3), 363–377.

Rosa, M., & Orey, D. C. (2010). Ethnomodelling: A pedagogical action for uncovering ethnomathematical practices. *Journal of Mathematical Modelling and Application, 1*(3), 58–67.

Rosa, M. & Orey, D. C. (2011). Ethnomathematics: The Cultural Aspects of Mathematics. *Revista Latinoamericana de Etnomatemática, 4*(2), 32-54.

Rosa, M., & Orey, D. C. (2012). An ethnomathematical study of the symmetrical freedom quilts. *Symmetry: Culture and Science, 23*(2), 191–220.

Rosa, M., & Orey, D. C. (2015). A trivium curriculum for mathematics based on literacy, matheracy, and technoracy: An ethnomathematics perspective. *ZDM*, *47*(4), 587–598.

Rosa, M., & Orey, D. C. (2016). Innovative approaches in ethnomathematics. In M. Rosa, U. D’Ambrosio, D. C. Orey, L. Shirley, W. V. Alangui, P. Palhares, & M. E. Gavarrete (Eds.), *Current and future perspectives of ethnomathematics as a program* (pp. 18–23). ICME13 Topical Surveys. London, England: Springer Open.

Seah,W. T., & Bishop, A. J. (2003).Values, mathematics and society: Making the connections. *Prime Number*, *18*(3), 4–9.

Septianawati, T., & Puspita, E. (2017). Ethnomathematics study: uncovering units of length, area, and volume in Kampung Naga Society. In *Journal of Physics: Conference Series 812*(1), 012021. IOP Publishing.

Sharma T., & Orey D.C. (2017) Meaningful Mathematics Through the Use of Cultural Artifacts. In. Rosa M., Shirley L., Gavarrete M., Alangui W. (Eds.) *Ethnomathematics and its Diverse Approaches for Mathematics Education.* (pp. 153-179). ICME-13 Monographs. Springer, Cham.

Sharp, J. M. (1999). A Teacher-Researcher Perspective on Designing Multicultural Mathematics Experiences for Preservice Teachers. *Equity & Excellence, 32*(1), 31-42.

Shockey, T. L. (2002). Etnomatematica de uma classe pro fi ssional: Cirurgiões cardiovasculares [Ethnomathematics a Professional Class: Cardiovascular

Surgeons]. *Bolema, 15* (17), 1–19.

Shuaibu, G. (2014). Mathematics in Hausa culture: some examples from Kano State-Nigeria. *IOSR J. Math. (IOSRJM), 10*(2), 167-171.

Sunzuma, G., & Maharaj, A. (2020). In-service mathematics teachers' knowledge and awareness of ethnomathematics approaches. International Journal of Mathematical Education in Science and Technology, 1-16.

Supriadi, S. (2019). Didactic Design of Sundanese Ethnomathematics Learning for Primary School Students. *International Journal of Learning, Teaching and Educational Research, 18*(11).154-175.

Supriadi, S. (2020) Pre-service elementary teachers: analysis of the disposition of mathematical modeling in ethno mathematics learning. *Elementary Education Online*, *19*(3), 1407-1421.

Supriadi, Suryadi, D., Sumarmo, U., Rakhmat, C. (2014). Developing Mathematical Modeling Ability Students Elementary School Teacher Education through Ethnomathematics-Based Contextual Learning. *International Journal of Education and Research, 2*(8), 439-452.

Wedege, T. (2010). Ethnomathematics and mathematical literacy: People knowing mathematics in society. In C. Bergsten, E. Jablonka, & T. Wedege (Eds.), *Mathematics and mathematics education: Cultural and social dimensions: Proceedings of MADIF7, The Seventh Mathematics Education Research Seminar, Stockholm, January 26 – 27, 2010* (pp. 31–46). Linköping, Sweden: Svensk Förening för Matematikdidaktisk Forskning (SMDF).

Widada, W., Sunardi, H., Herawaty, D., Boby, E., & Syefriani, D. (2018). Abstract Level Characteristics in SOLO Taxonomy during Ethnomathematics Learning. *International Journal of Science and Research, 7*(8), 352–355.

Widada, W., Herawaty, D., Anggoro, A. F. D., Yudha, A., & Hayati, M. K. (2019, April). Ethnomathematics and outdoor learning to improve problem solving ability. In *International Conference on Educational Sciences and Teacher Profession*, 295, 13-16. ICETeP 2018. Atlantis Press.

Verner, I., Massarwe, K., & Bshouty, D. (2013). Constructs of engagement emerging in an ethnomathematically-based teacher education course. *The Journal of Mathematical Behavior, 32*(3), 494–507.

Vithal, R., & Skovsmose, O. (1997). The end of innocence: A critique of "ethnomathematics". *Educational Studies in Mathematics, 34*, 131–158.

Yolcu, A. (2019). Kültürel olarak duyarlı matematik etkinlikleri. In Y. Dede, M.F. Doğan & F. Aslan-Tutak (Eds.), *Matematik Eğitiminde Etkinlikler ve Uygulamaları* (pp. 467-487). Ankara: Pegema Yayıncılık.

Yusuf, M. W., Saidi, I. ve Halliru, A. (2010). Ethnomathematics: a mathematical game in the Hausa culture. *International Journal of Mathematical Science Education*, *3*(1), 36-42.

Functional Mathematics Skills: an Essential Tool for Functional Education and Development in Nigeria.

Onoshakpokaiye, E. Odiri
Delta State University

Introduction

Education has been seen as an important instrument or the main engine through which any individual or nation can be developed. As a driving force for national development, no responsible government would overlook its education system. It is the citizens that bring about positive changes and contribute to the economic growth and development of the society or nation. These can only be achieved through functional education and developing in the citizens mathematics functional skills to enable them contribute meaningfully to the development of the nation. It is the citizens that translate the educational values to change the environment which he/she resides, therefore education does not take place in isolation (Efurhievwe. 2012).

Development of any nation lies on the type of education the citizens are exposure to. The role education play in the social, economic, political, and cultural development cannot be overemphasized. Functional education is an educational experience that focused on the identifying situational problems, collecting information for decision making in a world of challenges and enable the learner acquire mathematics functional skills, knowledge and attitudes for meaningful co-existence, sustainability and developments (Adewale, 2014, Agbowuro, Shuaibu and Jimwan, 2017).

What are Functional Mathematics skills?

Functional Mathematics skills are practical skills acquired in mathematics to enable the individuals work confidently, effectively and self-dependent in life. Functional skills is about knowing when and how to use the acquired knowledge and these skills in real-life situations. The learner can develop these skills through adapting and applying what they have learned to suit different situations that they will face in life (Functional Skills Support Programme (FSSP,2008).

According to Functional Skills Support Programme (FSSP, 2008) Functional mathematics requires the learners to use mathematics in ways that will make them to be effective, involved as citizens, operate confidently in life and to work in a wide range of contexts. FSSP (2008) went further to say that “for mathematics to be useful, learners must have the skills and confidence to apply, combine and adapt their mathematical knowledge to new situations in their life and work.” Functional mathematics skills are very important in the learning of mathematics, these skills enables the students to tackle practical problems and challenges of life which he/she may encounter either at home or in his/her education (FSSP, 2008). These skills assist us when we make purchases in our daily dealings and also very important to all our everyday lives. It is a key to success, open doors to learning, to work and to life. FSSP (2008), stated that “Mathematics Functional skills are based on a problem-solving approach and which can be developed in a practical way through discussion, thinking and explanation, right across the curriculum.”

Functional mathematics skills is of great importance in the sense that it develop the students to be self-dependence, enable them to manage in a different situations, develop employable skills and give a solid or sound basis for further learning or training. Mathematics Functional skills entails identifying problems or challenges in mathematics, selecting from the knowledge that we have gained and apply that knowledge to find possible or effective solutions. Students who are functionally skilled mathematically are able to apply the mathematics they know to solve problems that arises in their life and work.

According to Webster (2019), “Functional mathematics skills are those skills that students need to live independently in the community, care for themselves, and make choices about their lives.” Everyone ability to live an independent life depends on our understanding of mathematics basic concepts. We use mathematics all the time in our everyday living. Functional mathematics skills are skills to live an independent life, it helps us to contribute or improve our society and make us to be gainfully employed. Functional mathematics skills help us with the practical mathematics skills that are useful in our education, place of work and in everyday life.

Concept of Mathematics

Mathematics has been describe as an indispensable tool for the development of any society, it is the basis for science and technology, its knowledge and skills are the bedrock of the societal transformation that can transform ideas to reality (Otunu-Ogbisi and Ukpebor,2009). Abubakar, DogogoWokoma and Afebuame(2012), stated that many branches of mathematics have useful application in all fields of human endeavour and its basic operation play an important roles in assisting the learners to make sense of the world around them. According to Omoruan (2014) “these basic operations extend the notion of numbers to create tools to model situations and solve problems in our daily lives. Without the sense of numbers and its operations solving problems would have been impossible.” No functional education can take place without the application of mathematics. Mathematics remains the basis for all sciences and every subjects that involve calculations. Training in schools cannot be applicable without the use of mathematics and it remains the tool for functional education and national development.

For an individual to acquire appropriate skills to contribute to the development of the society or nation such individual need mathematics and its skills,

Concept of Education

According to Agbowuro, Shuaibu and Jimwan (2017) “The role of education as the foundation of social, economic, political, and cultural development is undisputed.” No nation can develop beyond its educational standards or level, education is the bedrock of socioeconomic and political development of a nation (Agbowuro, et al, 2017, Joseph and Joseph, 2018). The authors went further to say that success of many nations made today in tackling major developmental problems such as poverty, unemployment and among others is as result of functional education system. Developed countries like China, Japan, Russia, and United States of America and many others made their various achievement through their commitment to ensuring a functional education system in their countries. These nations were able to overcome several developmental challenges like poverty, unemployment, ignorance etc. with the aid of good education system (Agbowuro, et al, 2017, Joseph, et al, 2018).

Education is one of the enduring legacies that any nation can bequeath to the future generation. It is a means in which the norms and values of any society can be transmitted to the younger generation. Maduegbunam and Okafor (2014) sees education as “the process by which knowledge and skills are acquired.” Okafor (1992) in Maduegbunam, et al (2014) defined education as a process of acculturation through which the individual is helped to attain the development of his potentialities and their maximum activation that will enable the society meet their developmental needs.

Nwaka (2015) sees Education as an instrument of change for any nation and main engine for the development of an individual or nation. The development of any nation depends on the kind of education the citizens are exposed to. Many nations like USA, Britain, Russia, France and Germany and many others that have advanced technologically today is as result of functional education.. For the citizens of any nation to be productive and self-reliant, there is the need for a functional education. Nigeria and many other developing countries are yet to quite achieve their set goals. These nations are impoverished and underdeveloped because they lack functional education system (Obiora, 2010), According to Nwaka (2015), “Nigeria needs education that would be practical and skills development-oriented or functionally-driven to fortify its youths with skills needed to perform contemporary tasks.” According to Agbowuro, et al (2017), “Education raises people’s productivity and creativity and promotes entrepreneurship and technological advances. The economic growth of a country largely depends on technological improvement and on its scientific and technical manpower.”

The Nigeria Policy on Education stated some of the educational goals as “the inculcation of national consciousness, values and national unity; and development of appropriate skills, mental, physical and social abilities and competencies to empower the individual to live in and contribute positively to the society" (FRN, 2013). Nigeria has many form of educational system as stipulated in the Nigeria Education Policy namely: Basic education comprises

1. Early Childhood Care, Development and Education(ECCDE), This are the children between age 0-4 years in a crèche or nursery

2. kindergarten one year education given to children aged 5 in preparation to their entering into primary school.

3. Primary Education, the duration is 6 years. The primary education is universally free and compulsory for every citizens and is from ages 6-12. It is the foundation of every other educational levels. It is the key to the success or failure of the whole education systems.

4. Junior Secondary Education is of 3 years duration. The objectives is "to inculcate permanent literacy, numeracy and the ability to communicate effectively; lay a sound basis for scientific, critical and reflective thinking; provide opportunities for the child to develop life manipulative skills that will enable the child function effectively in the society within the limits of the child's capacity; provide the child with diverse basic knowledge and skills for entrepreneurship and education advancement etc."(FRN, 2013)

Senior Secondary Education is of 3 years duration. Some of the objectives are: to " provide trained manpower in the applied sciences, technology and commerce at sub-professional grades; provide entrepreneurial, technical and vocational job specific skills for self-reliance, and for agricultural, industrial commercial and economic development" (FRN,2013). It prepares individuals for higher education,

1. Mass literacy, Adult and Non-Formal Education ii) nomadic education, comprises all forms of Functional education given to youths and adults outside the formal school system:

2. Tertiary Education comprising university education, teacher education, technology education and innovation enterprise institution.

It is unfortunate that upon all the well-structured education system with its goals and objectives as stated in the Nigeria National Policy on Education, there is still the problem of implementation and goals achievement. Most of her university graduates are unemployed. What they studied at the tertiary institution cannot be applied to the society they live in as result of the type of educational knowledge and the kind of education they are exposed to in the schools. Most of the graduates lack the mathematics functional skills to be self-reliant and self-dependent, as result they remain unemployed. When functional education is inculcated in the students it will address the practical needs of the nation and invariably result to economic prosperity increased. Omolayole (2002) pointed out that Nigeria needs to increase her efforts to improve her educational systems at all levels and make it more functionally-oriented.

Concept of Functional Education

Functional education is that education that is relevant, prepares the individual to face his social goals, economic realities and future life challenges positively. It is an education where emphasizes is on the ability to perform productive tasks. Abdu (2005) stated that functional education is the wholesome training of an individual that makes him/her to be productive and contribute to his/her community and the nation as a whole. Functional education attempts to train learners towards the practical mastery of any studied subjects in order to get them into the habit to adapt to any situation (Omoruan, 2014). With the increase of specialized universities, polytechnics, colleges of education (technical) and Schools' curriculum innovation, most of the graduates are still roaming the street as result of lack of functional mathematics skills.

Idowu (1999) in Joseph, et al (2018) define functional education "as the total process of bringing up individuals to develop their potentials (cognitive, affective and psychomotor) to the fullest and consequently be able to contribute maximally to the development of the society." Arogundade (2011) stated that functional education seeks to prepare people to be responsible and enterprising individuals especially the youth to become entrepreneurs that will contribute to the development of the economy. Many of the developed countries' universities and technical colleges trained their students and they are well-grounded in mathematics functional skills that enable them contribute and build or develop their nation. But Nigeria is the reverse, most of the graduates are not well grounded in this aspect, it may be due to memorization to pass examination and so they turned out from the tertiary institution without mathematics function skills that will enable them contribute to the development of their society or nation and so they come out unemployed. Maduegbunam, et al (2014) define Functional education as that type of education that equips the individuals with the knowledge and skills needed for the performance of productive tasks.

Cookey as cited in Joseph, et al (2018) defined functional education as the education where emphasis is lay more on the ability to perform productive tasks than theory, here emphasizes is on practical skills. According to Maduegbunam, et al (2014) "Nigeria education has not been functional because too much emphasis has been placed on theoretical and academic knowledge. There is also undue emphasis on the possession of certificates instead of on what one can do." School programmes need to be relevant, practical and comprehensive for the acquisition of functional skills and development of mental, physical, social abilities for the individual to live in and contribute to the society development(Udoh & Akpan, 2014, Agbowuro, et al 2017)).

Functional education produces graduates who are entrepreneurs and self-dependent and ready to put into practice what they have been taught or learned in the university which eventually make them to be self-employed and employers of labour. Through functional education the welfare of the citizens are improved, there is economic growth, science and technology advancement, and more employment for the citizens to generate income towards the development of the nation. For education to be functional according to Minzer (1992), the education should be relevant to the needs of the society or nation and high level man power should be trained to contribute meaningfully towards the overall progress of the nation. The outcome of this type of education where graduates are produced with theoretical knowledge and no practical or mathematics functional skills is unemployment and backwardness in national development.

Characteristics of Functional Education

The purpose of functional education is for the individual to apply his/ her mathematics functional skills to be productive and contribute to the national development. Fuandai, Shiaki & Gbari (2007) listed some characteristics of functional education as follows:

Relevance: Education is relevance if it is relevant to the immediate and future needs of the individual and the society in which he/she resides, able to solve the individual's everyday problems, meet the needs of the learners and improves the quality of life of the individual and the society. The mathematics functional skills the individual has acquired must be relevant and solve his/her everyday problems and meet his/her needs.

Acquisition of Practical Skills and Knowledge: Functional education entails the application of mathematical functional skills and knowledge to complex situation rather than just ordinary use of facts, memorization and procedures, it is practical oriented. This implies that the mathematical skills acquired through training could easily be put into use whenever the need arises. The implication of mathematics functional skills and functional education is that the learner can be self-employed, self-reliant and also contribute effectively to the national development after completion of his or her education

Self-reliance: Functional education and Functional mathematics skills prepares and equips learner to be self-dependent, self-reliance, applying and using their mathematical knowledge and skills acquired to contribute to the economic and national development. It create wealth and employment opportunities for the learner. With Functional mathematics skills and functional education poverty and crimes can be reduced among the youths.

Obstacles to Functional Education in Nigeria

The standard of education has deteriorated instead of improving, which adversely affect the development of Nigeria as a nation. There are some factors that are responsible to this falling standard. Fanon (2005) emphasized that the current system of education in Nigeria lacks emphasis on productive functional skills at both the junior secondary, senior Secondary and tertiary levels of education. The system of education in Nigeria concentrate more on theory than practical. Although in the curriculum there is provision for practical skills but this aspect is being neglected.

Failure to Implement Education Policy, Suggestions and Recommendations for Improving Education in Nigeria

Most suggestions and recommendations that are made by the educationists and prominent scholars for improving education were usually neglected due to ignorance, politics and corruption. There are good education policy and planning to attain functional mathematics as stipulated in the national policy on education. Our policy maker are good in planning but the problem is implementation. The government is not ready to spend money on education for this reason, most of the suggestions and recommendation are not implemented. Nwaka (2012) suggested that there is need for the overhauling of the educational programmes and the implementation process so as to ensure that the curriculum is relevant and functional

Teacher Factor

Nwaka (2015), stated that "Many teachers do not adapt their teaching-learning programmes and processes to meet the challenges of changing technological advances and current needs. Most often they neglect the use of variety of teaching methods and repeated practice of tasks by which learners grow in skills acquisition." Teachers are regarded as reservoirs of knowledge and so when the teacher lack the knowledge of the subject matter or inefficient it will be difficult for him/her to function effectively in the society. You can only give what you have, for this reason no teacher can give what he/she does not have. Onyeachu (2009) observed that there is urgent need of teacher in Nigeria, teacher with determination and dedicated that can transform her citizens and become employable, set up their own entrepreneurship business and also contribute towards the progress of the nation.

Inadequate funding of Education

According to Nwaka (2015), it is no more news that funding of education programmes in Nigeria is inadequate and this calls for pity because the problem of education has continued to worsen day after day. Funding is a central factor to an effective functional education. He went further to say that every level of education in Nigeria complain about poor infrastructures, dilapidated classrooms, poorly equipped libraries and laboratories that will aid effective functional education. The education is not properly funded, lack of educational equipment/facilities, teaching materials and also the teachers and students are not effectively motivated in the school.

Too much emphasis on paper qualification

Since emphasis is on paper qualification, many Nigerians attends school for the purpose of obtaining certificates but not the knowledge and mathematics functional skills needed for the improvement or development of the nation. Maduegbunam, et al (2014) stated that "Very few Nigerian graduates from Nigerian schools, but cannot defend the certificates which they claim to have obtained." Ezeh (1997) cited in Maduegbunam, et al (2014), stated that the country still lacks qualified or skilled Manpower because what the institutions are producing are merely graduates who possess certificates but lack the knowledge and mathematics functional skills. He laments that many Nigerian students are not hard working enough to struggle for the acquisition of practical knowledge that will enable them contribute to the progress or national development.

The Educational Curriculum

The curriculum of Nigeria education need to be re structured and re organized to meet the present needs of the nation so that people who are exposed to it can acquire knowledge and mathematics functional skills to enable them contribute meaningfully to its development. Emphasis should be laid on the development of the indigenous language. Most of the scientific terms that are taught in schools are too complex or difficult for the students to understand, since it is not their indigenous language. These scientific terms need to be explained in their indigenous languages to make it clearer for easy understanding. Although English is important but the indigenous languages being the first language spoken by the students should be encouraged to facilitate effective teaching and learning process. Using English language as the first and only means of communication at both lower and higher level of education hinders teaching and learning, therefore affect ability to communicate in the classroom or lecture halls.

The Education Management and Administrative Factor

Administration, according to Maduegbunam, et al (2014) "concerns with the act of controlling or directing affairs for the purpose of achieving a stated goal. The quality of administration in education affects the quality of education as well as the products of schools." According to the authors the way these aspects of education is being handle has great influence on the quality of education that nation will have. For quality education and national development there must be sound educational policies that must be properly implemented. Also before educational programmes or policies are introduced good and result-oriented educational plans should be made.

The present Universal Basic Education is not well implemented, the educational objectives as stated in the education policy are yet to be achieved. According to the policy, at the completion of the junior secondary school (JSS) level the students were supposed to learn a particular skills that will enable them to be self-employed, that is why introductory technology and vocational subjects were introduced. These subjects were being taught theoretically due to lacks of equipment/laboratories and mathematics functional skills. Functional education requires very good educational planning, management and administration. Regular and effective supervision of what goes on in the school system be it lower or tertiary institution is a must for the achievement of functional education. There is insufficient supervision of all that affect the education system, those important offices that are responsible for handling education matters in Nigeria carried out little or no supervision (Maduegbunam, et al, 2014)

Politics in Appointment

When appointments of heads of these commissions and boards overseeing education are made, in most cases, 'Nigerian factor' comes into play, this sometimes influences the choice of who becomes the heads, and they are not appointed based on merit. The interest of the nation are not put into consideration. Some of those appointed as heads or supervisors are not qualified or non-professional, the people they are supposed to be supervised are even more knowledgeable than them because they were appointed based on " Nigerian factor" or through god-fathers, as result no much work is done by them. When these heads or supervisors are found wanting nobody touch them because they have god-fathers who will defend them. In this situation. Functional education cannot be achieved, it can only be achieved when there is proper supervision. For Nigeria education to function the managers, supervisors and administrators of education must be professionally qualified, well experienced, dedicated and morally sound, otherwise reverse will be the case.

The Quality of Teachers

Teachers are those implementing the functional curriculum, without dedicated teachers the curriculum will be meaningless invariably Functional education cannot be achieved anywhere in Nigeria. There are various educational institutions that are responsible for the training or production of teachers. We have the Colleges of Education, National Teachers Institutes (NTI) and faculty of education in the universities. According to Maduegbunam, et al (2014), "however, there is little or no emphasis on the quality of what are eventually produced as teachers in these institutions. Also, there is little or no emphasis on the welfare of these teachers as professionals on whom the quality of

Nigerian education is hinged".

Some of these graduates that are produced, applied to study education not that they really have the interest in teaching, but because they were not admitted in the right course they wanted to study and so after their graduation they have little or no interest in the teaching field. How can these type of teachers function well? More so some of the graduates are not actually taught with the needed education materials due to government inability to equip and provide funds for the institutions and so they graduate without mathematics functional skills to practice when they are employ in their various schools.

Some of these teachers that are employed are not professionally qualified to teach in the school, they may be educated but by merit, they are not supposed to be employed. But these teachers are employed based on tribalism, nepotism and god- fathers leaving the qualified ones behind. In this situation there is no way they can function well in the teaching profession and the resultant effect is education that is not functional.

Lack of Teaching Professionalism

Apart from production of quality teachers, another problem affecting functional education in Nigeria is lack of teaching profession. Many developed and developing countries recognized teaching as a profession, but in Nigeria teaching is only recognized as profession in theory. Although there is a professional body called Teachers Registration Council of Nigeria (TRCN), this body has not be able to really control the intake of teachers into teaching profession. The federal and state government are still employing non-professional into the teaching field leaving the trained ones.

Apart from the government factors, most of the private schools in Nigeria are the worst, they employ anybody, and they don't care whether you study education or not. Worse still they even recruit teachers to subjects that are not their area of specialization. How can there be functional education? How can these teachers be efficient or effective without knowing the rules, ethics and regulation guiding teaching? To achieve functional education in Nigeria, teaching profession needs to be controlled by TRCN and restricted to only professional in the field. It is only those that have been trained in the field that can make the education to be functional, teaching is beyond talking and writing on the board. There cannot be functional education anywhere where there is lack of well-trained professionally qualified and dedicated teachers.

Lack of Infrastructures/ Inadequate Educational Facilities

According to Maduegbunam, et al (2014) **"**Educational facilities are important for functional education. Teaching and learning facilities must be available and must be of good quality for the achievement of good quality education." Many schools in Nigeria today, from the lower level (primary) to tertiary institution lack most of the essential education materials needed for teaching and learning to take place. Most of the Primary, secondary school and tertiary institution lack good infrastructural facilities. At the primary and secondary level, no enough classroom, chairs and laboratories. The tertiary institution are even worse, they lack good lecture theatre or lecture halls, no good hostel accommodation, lack well-equipped Science and technology laboratories, libraries and other education learning materials that will facilitates teaching and learning. Most of the courses are taught in theory and so students find it difficult to match theoretical knowledge with practical skills. In most cases, the available equipment are obsolete as result of technological advancement. This is the reason why Academic Staff Union of Universities (ASUU) have been calling on the federal and state government to fund and equip the Nigeria universities to be measurable to universities in other countries, so that proper teaching and learning can take place and make Nigeria education to be more productive and functional, but still the government pay deaf ears to the plight of ASUU accusing them of always going on strike. Why will the government not pay deaf ears to the plight of ASUU? They send their children to study abroad. Functional education emphasizes on practical activities, this can only be achieved through proper funding of education, very good accommodation for the staff and students, good teachers or lecturers ‘well package, well-equipped laboratories, libraries, and provision of other instructional materials that will facilitate teaching and learning.

Admission Irregularity

The problem of Nigeria education is that of preferential treatment given to one section of the country. Students will be exposed to the same standardized examination but at the end, student A, who scored a lower mark will be given admission leaving student B who scored higher mark in the same examination because he/she is not from a particular geo-political zone in the name of “educationally disadvantage”. How can there be a functional education when the rightful candidates are not admitted and less intelligent ones is given admission at the expense of the most intelligent ones. What do we expect from such student? Since that student is admitted based on geo- political zone, such student will also be managed to graduate and eventually he/she will also be less productive without mathematics functional skills. The Nigeria National Policy on Education did not stipulates that preference should be given to one part of the country, all the students are exposed to the same curriculum and external examination why these disparity. A functional education is based on quality but not inequality during admission.

Conclusion

No nation can develop without functional education system. There is need for proper planning and supervision to ensure that the stated objectives are achieved. More emphasis should laid on mathematics functional skills or practical skills. All these stated objectives in the national policy on education can only be achieved through effective and functional education. For any nation, be it developed or developing nation need high quality or functional education for her to develop and maintain the standard they have attained it in terms of economic growth, and science and technology advancement.

Functional education remains the key to development of any nation. Nigeria must therefore use all the resources at their disposal to ensure that the current education problems in the country are properly address so that there can be functional education which will eventually develop the nation.

Recommendations

Functional education, being the key to national development can be achieved in Nigeria if the following recommendations are taken into consideration

All the important suggestions and recommendations that are made as per improving the educational programmes in Nigeria should be properly looked into and implemented by those in charge of implementation.

The federal and state Government should improve on the conditions of service of the teachers/lecturers. They should be involved or consulted in decision making on education policy, planning/formulation so as to attain functional education for functional skill and national development since they are the one implementing the policy.

The Government should take the issue of funding education as a priority, this should not be swept under the carpet. The government should provide educational infrastructures, facilities and education learning materials in order to achieve functional education and national development.

Government should organized workshop for the teachers on functional skills and send them out for in-service training to enable them adapt to the current trend in teaching-learning to meet up with the current societal needs and technological advancement.

The citizens should be encouraged to study mathematics, science subjects, science and technology and other courses that will help them to be self-reliant so as to contribute to the economic growth and national development. This can be done through scholarship

Government should ensure that only dedicated and professionally qualified teachers are recruited into the teaching field to ensure that functional education is attained.

Mathematics functional skills should be inculcated on the students to enable them contribute to the society or to be self-dependent. This can be done through encouragement or proper training of the students to study mathematics. The mathematics teachers or lecturers should ensure the students are taught with practical or good mathematics instructional materials.

References

Abdu, A. (2005). Functional secondary education for self-reliance. The way forward. *Multi-dimensional Journal of Research and Development, 5 (1)*, 101-108.

Abubakar, R.B. DagogoWokoma, S.A & Afebuame, A.O. (2012). Mathematics: A pivotal rebranding tool for national development. *Academic Research International. 2(3)*, 344-351

Adewale, S. O. (2014). Using functional education to synergize religion, economy, and politics towards achieving and sustaining excellence in a globalize Maley and Islamic world. *Asian Journal of Social Sciences and Humanities, 3*(2), 192-200.

Agbowuro, C., Shuaibu, S. & Jimwan, C. S. (2017). Creative and functional education: the challenges and prospects in a comatose economy. *Journal of Education and Practice, 8(8)*, 38-40

Akumah, E. (1992), Concepts of Functional Education. In Okafor, R. C. & Emeka, L. N. (eds.) *Nigerian Peoples and Culture* Enugu, Nigeria: New Generation Ventures Ltd.

Arogundade, B.B. (2011). Entrepreneurship Education: an Imperative for Sustainable Development in Nigeria. *Journal of Emerging Trends in Educational Research and Policy Studies (JETERAPS), 2*(1)*, 26-29.*

Ezeh, G. C. (1997). The Role of Teachers in National Development. Paper presented at the Teachers' Forum, C.S.S. Eha-Ohuala.

Efurhievwe, F. A. O. (2012). Utilization of education values for the development of national stability through democratic process. *Nigeria. Journal of Qualitative Education. 8* (2), 75-79.

Fanon, J. (2005). Investing in Africans future through its Universities. *This Day. 18.*

Federal Republic of Nigeria (2013), *National Policy on Education (6th edition),* Lagos: NERDC Press

Fuandai, C. M., Shiaki, B. & Gbari, U. S. (2007). Functional education as a spring board for national development. *Multi-dimensional Journal of Research and Development .5*(2), 147-150.

Functional Skills Support Programme (FSSP) (2008).*Resources to support the pilot of functional skills teaching and learning functional mathematics.* Retrieved from https://www. ncetm.org.uk

Idowu, A. (1999). *Functional Educational and Nation Building: The challenge of the Next Millennium.* Lead Paper presented at the 4th National Conference of the Federal College of Education, Kontagora. September 8.

Joseph, M, M. & Joseph, S. (2018), Functional Education as a Tool for Sustainable Development in Nigeria: Implication for Curriculum Planners. *KIU Journal of Social Sciences 4(4)*, 27- 34

Maduegbunam, T. O. & Okafor, N.M. (2014). Functional education: an essential tool for bridging the gap in education in Nigeria, *Academic Discourse: An international journal, 7*(1), 1-12.

Minzer, K. (1992). Making development more sustainable: sustainomics frame work application.Retrieved From http://www.esearth.org/artic le/sustainable/ development-triangle .

Nwaka, N. G. (2012).The state of tertiary education in meeting the needs of the modern Nigeria society. In 0. Ibcnerne, B. Alumode & H. Usoro (Eds). *The state of education in Nigeria*. Kano: West and Solomon Publishing Coy Ltd.

Nwaka, N. G. (2015). Functional education for national development: imperativeness and challenges. *Journal of Pristine. 10(1)* 1-11

Obiora, O. M. (2010).The role of education in sustainable development of Nigeria: A philosophical appraisal. *Journal of Educational Studies and Research. 5*(1). 174-189.

Okafor, R. G. (1992), Concepts of Functional Education. *Journal of General Studies 1*(3)

Omolayole, M. 0. (2002). Education for character and skills development. In E. A. Yoloye & A. 0. Osiyale (eds). *Education for character and skills development*. Fafunnwa Educational Foundation Series.

Omoruan, B, E. (2014). An examination of numeracy in facilitating functional skills in student for national development. *Research in Education. 20(1)*, 203-207

Onyeachu, J. A. E. (2009). Refocusing tertiary education in Nigeria towards entrepreneurship education: challenges for the 21st century in P. Egbule, J. E.Tabotndip & D. A. Aboho (eds). *Refocusing education in Nigeria in the 21s'* *century*. Kano: West & Solomon Publishing Coy. Ltd.

Otunu-Ogbisi,R.A. & Ukpebor, J.N.(2009). Mathematics education: a tool for technological development in Nigeria Abacus. *The journal of Mathematical Association of Nigeria. 34(1,)* 46-53

Webster, J. (2019). Functional Math Skills That Support Independence Retrieved from https://www.thoughtco.com/functional-math-skills-that-support-independence-3111105

Out-of-School Mathematics Environments

Ceylan Sen
Yozgat Bozok University
Gürsel Guler
Yozgat Bozok University

Formal Learning, Non-Formal Learning, and Informal Learning

Formal learning is generally defined as learning carried out in schools and professional development programs based on the environment in which teaching is carried out. Informal learning, on the other hand, is defined based on formal learning and creates a tautological relationship. Informal learning environments are informal environments, and the reverse is also true. In this regard, learning in informal environments is referred to as informal learning. Bransford, Barron, et al. (2006, pp. 48-49) describe informal learning as follows:

> "Informal learning is human-oriented and subjective. Thanks to its subjectivity, it is related to the performance and individual characteristics of the person. Informal learning involves affective and cognitive integrated participation. This is because knowledge cannot be treated independently from the person."

The image of formal learning is familiar to all of us: A classroom, desks, students at desks, and a teacher. In formal learning, students are classified hierarchically based on age, grade, etc. Illich (1970) states that formal learning is based on three elements: i) students belong to the school, ii) students learn in schools, iii) students can only learn in schools. However, he criticizes the classification of students by age, pointing out that this disrupts learning. Instead, he argues, learners should come together to explore based on their interests and curiosity regardless of their age.

Is informal learning "informal" only because of the environments in which it takes place? Is it just a type of discourse? Or is it real learning? In general, informal learning refers to learning and teaching that takes place separately from official certification and curriculum institutions (Tan, 2010). The presence or absence of the curriculum is generally determinant in informal learning. Informal learning is any activity that involves the search for knowledge or skills without an externally imposed curriculum and criteria (Livingstone, 1999).

The Learning in Informal and Formal Environments (LIFE) Center recommends looking at where most learning takes place apart from formal learning environments to understand how people learn (Banks et al., 2007). Accordingly, it is necessary to clarify new ways in people's learning and the role of context in learning (Bransford, Vye, et al., 2006). Eshach (2007) classified out-of-school learning into two categories: Non-formal learning and informal learning. Non-formal learning is a planned form of learning performed for a specific purpose (learning goals, time) in both formal and informal environments and is positioned between formal and informal learning. Eshach (2007) summarizes formal, non-formal, and informal learning environments as in Fig1.

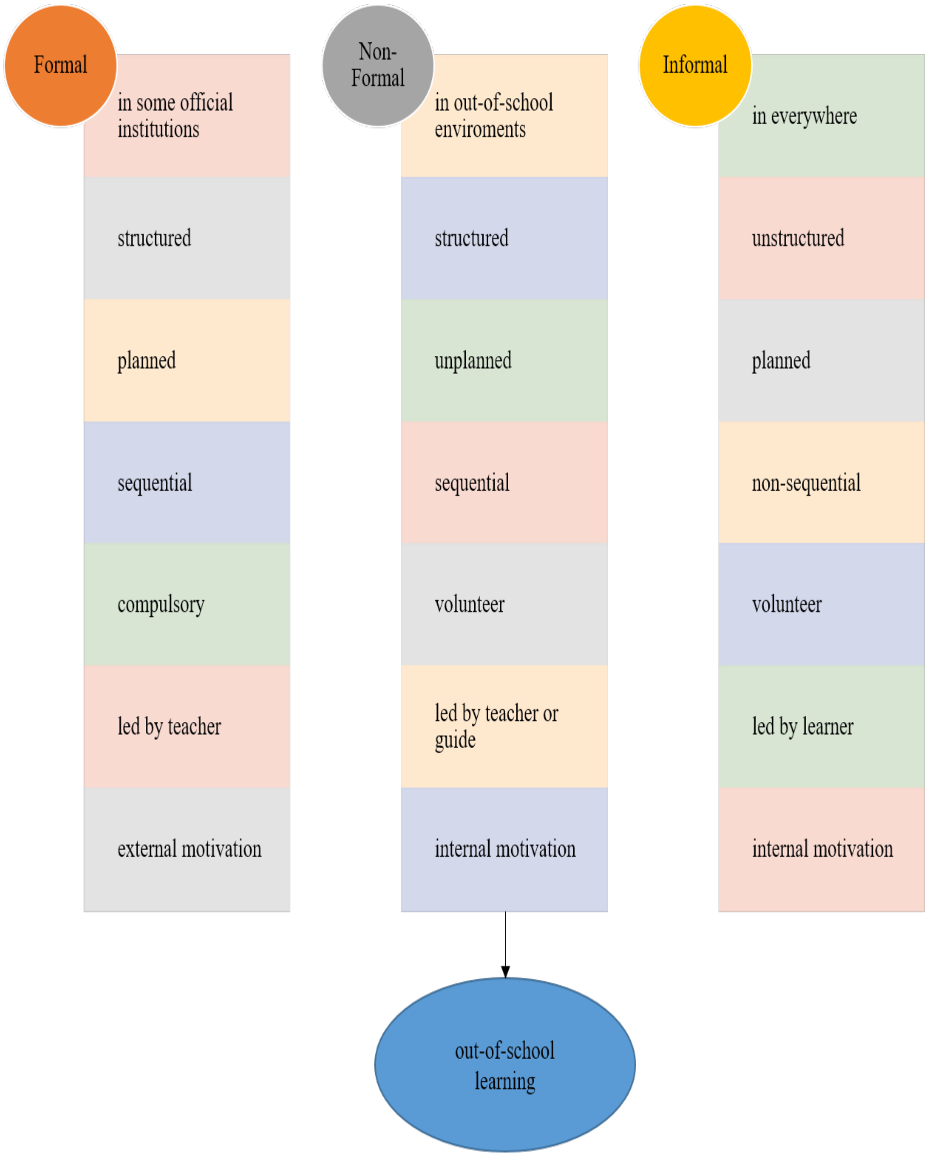


Figure 1. Properties of Formal, Non-Formal and Informal Learning.

While non-formal learning is carried out in institutional areas outside the school that can be visited in certain periods, informal learning is conducted in non-institutional areas around us that can be visited any time (Tal & Morag, 2009). Non-formal learning environments are environments that support individuals' learning and allow the structuring and development of knowledge. These environments offer individuals an effective learning setting under the leadership of a teacher or a guide. Informal learning environments involve learning processes that occur spontaneously in life. It is haphazard, not purposeful and planned. Individuals unconsciously learn new things through the situations they encounter and their interactions with the members of the groups they are in. It includes learning that is conducted in a planned and adaptable way in environments other than the formal learning environment (school, classroom). It supports learning in school, that is, formal learning (Eshach, 2006). In non-formal learning, the individual decides what to learn, but there is a planner who decides how to learn (Mocker & Spear, 1982). According to Pilz, and Wilmshöfer (2015), non-formal learning takes place along with the mainstream systems of education and training, and usually requires no formal certification. Non-formal learning is a systematic educational activity carried out outside the formal education system for certain groups within the framework of specific goals (Coombs & Ahmed, 1974). The literature review shows that concepts such as out-of-school learning, out-of-school education, and out-of-classroom learning are used in place of non-formal learning. The environments in which learning takes place are exemplified in Fig2.

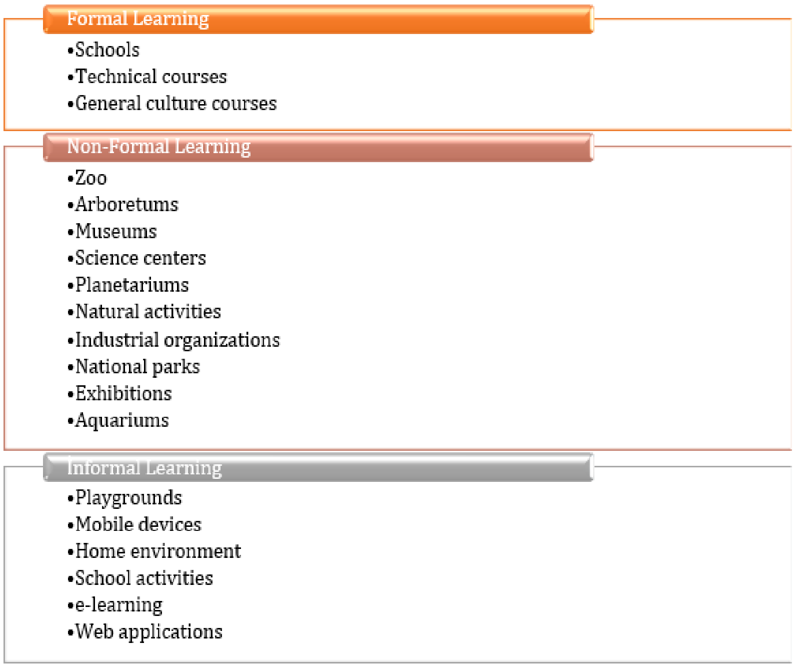


Figure 2. Learning Environments.

Out-of-School Learning

Out-of-school learning is a structured learning experience that is conducted out of the classroom environment after school or during holidays (Kendall et al., 2006). There are many out-of-school learning environments such as out-of-school games, projects in school areas, museum visits, science expeditions, historical and geographical field trips, and outdoor activities (IOL, 2008). All forms of out-of-school learning provide direct experience with real life, and such experience is real learning. Out-of-school learning allows learners to be active and provides learning based on discovery. Out-of-classroom learning is of primary importance in organizing and experiencing knowledge and is about not only what we learn, but also how and where we learn (DfES, 2006).

According to Rea (2008), out-of-school learning should not be considered as an extension of the normal classroom, but as an educational vision different from traditional schooling. Resnick (1987) emphasizes the difference between in-school learning and out-of-school learning as follows: "*Educating people only as good learners in school environments may not be enough for them to be strong learners outside the school*" (Resnick, 1987, pp. 18). Knowledge learned develops as a product of the activity it is in and of the context it is used in. Students have difficulty in applying the knowledge they have learned to both new situations and the daily life (Eshach, 2006). Accordingly, the context in which something is learned is an important part of what is learned. This view has important effects on schooling. Children will have trouble applying their knowledge outside of school when only learning that takes place in school is an element of classroom culture and students have no experience of dealing with real-world problems (Moffett, 2011). For this reason, it should be planned to involve more features that enable students to use the knowledge they learn in school outside the school.

Out-of-School Learning: Benefits and Barriers

Out-of-school learning is an integral part of the learning experience (Beard, 2006) and provides a unique context for students to develop a variety of skills. School lessons can be improved efficiently with the knowledge gained through out-of-school experiences. Out-of-school learning helps motivate students by providing opportunities for new experiences in the fresh air (Waite & Rea, 2007). Such experiences contribute positively to students' appreciation, creation of pleasure (Beard, 2006), and permanent learning (Waite, 2007). Students' physical development can be supported, and their coordination can be improved by offering them opportunities to exercise through out-of-school experiences (Waite & Rea, 2007). In this way, their mental and physical development is supported with natural contexts. At the same time, out-of-school experiences raise awareness of the environment (Rivkin, 2000). Out-of-school experiences contribute significantly to students' personal, social, and emotional development.

Apart from its above-mentioned significant benefits, outdoor learning also includes various barriers. Teachers generally do not trust out-of-school learning. Teachers' concerns about safety and health, time constraints, insufficient resources, and lack of support limit students' access to out-of-classroom learning (Rickinson et al., 2004).

Out-of-School Mathematics

Formal learning is the type of learning that a person (or a group) experiences through presence in institutional places and application of a structured education program. In these programs, the educator is the person who plans the teaching content and is responsible for teaching and assessment. K-12 school classrooms, courses, and professional development programs are examples of formal learning environments. Today, many educational practices are carried out within the boundaries of such formalized contexts. Similarly, mathematics education is conducted in schools and in a limited way (Martin, 2012).

A comparison between school mathematics and mathematical practices in daily life shows some disconnection between the two (Goldman, 2006). Knowledge in school generally develops based on transference by the teacher and is largely devoid of meaning (Masingila, 2002). In schools, more importance is given to transferring syntax (procedures) rather than teaching semantics (meaning). Students acquire knowledge without being aware of its equivalent in daily life. Students need out-of-school experiences to make sense of and improve the mathematical knowledge they have acquired. Similarly, in-school mathematical experiences are needed in order to formalize the mathematical experiences acquired outside of school (Schoenfeld, 1989). Meaningful learning is achieved with the integration of in-school and out-of-school mathematical experiences.

Today, students need mathematical experiences both inside and outside of school. In a similar vein, in-school mathematics teaching is needed for students to conceptualize and mathematically generalize their knowledge acquired in out-of-school environments. Such practices carried out in the classroom allow students to take part in the intellectual community and make inferences based on explanation and justification (Cobb et al., 1992).

The development of mathematical knowledge, skills, and understanding forms the basis for academic achievements needed in future and real life (Duncan et al., 2007). Many education systems conduct teaching in traditional ways and enable students to acquire the mathematical knowledge offered by the teacher in the classroom. Although the current education programs have adopted various practices, teachers are at the center of most teaching processes and transfer of knowledge is performed by them (Fägerstam, 2014; Waite, 2011). In addition, previous studies show that learning opportunities under the leadership of students and including various learning activities positively affect students' academic achievement and mathematics performance (Brooks, 2010; Cherry, 2011; Mantzicopoulos & Ala, 2013). Such learning increases students' intrinsic motivation towards school (Bølling et al., 2019; Fägerstam & Samuelsen, 2014; Unlu & Dettweiler, 2015). Current curricula (e.g. Ministry of National Education of Turkey [MoNE] Mathematics Curriculum, 2018 and Council for the Curriculum, Examinations and Assessment [CCEA], 2007) support mathematical knowledge, skills, and understanding through practices in various contexts. The curricula not only support real-life applications of mathematics but also highlight the use of real-life situations as meaningful contexts for mathematical ideas and activities. While these contexts involve students' activities and learning experiences, it is also state that the immediate environment and real life should be used to expand students' mathematics knowledge. Out-of-school learning activities make it possible to associate mathematics with real life. The advantages of out-of-school mathematical practices are presented below.

- They allow using heuristic methods apart from the written algorithms taught in school mathematics (Baker, 2007). In this way, an intellectual process is provided rather than a teaching based on rote learning.

- Students are aware of the accuracy or inaccuracy of what they do in out-of-school mathematical practices (Hoyles, Noss, & Pozzi, 2001). Students can tell the causes of their mistakes and correct them in out-of-school mathematical practices. In school mathematics, on the other hand, students do not tend to question the causes of the inaccuracy of the result, as they focus only on the correct answer through algorithms.

- Out-of-school mathematical practices can be applied and generalized to different contexts. Contrary to abstract and generalized mathematics, these practices allow knowledge to be structured and generalized by students themselves, who are allowed to experience the usage areas and differences of mathematical knowledge (Schliemann & Acioly, 1989).

- Out-of-school mathematical practices provide an opportunity to solve problems in different ways (Scribner, 1984). Students have the opportunity to try, apply, and choose different strategies relevant to a solution, without being bound to a single solution.

- Out-of-school mathematical practices are meaningful for practitioners. Numbers make sense because they are exemplified from real life situations. For example, students encounter real life problems like "Let's assume that we go to the grocery store and buy 2 apples. And then we buy 2 more apples. How many apples do we have in the end?" instead of numerical expressions like 2+2. Out-of-school mathematics has a close connection with the nature of mathematics in terms of context and meaning.

Out-of-school programs are included in "supplemental education services" in the No Child Left Behind Act (NCBL). These supplemental programs can be official and unofficial programs that provide flexibility for students to be academically successful and to overcome systemic problems in school (Good et al., 2014). Out-of-school learning environments can change negative experiences about school mathematics. These kinds of environments enable students to interact with mathematics and acquire the ways of knowing mathematics by socializing (Walker, 2012). In this way, students experience a different socialization process, thereby changing their mathematical identity and improving their positive attitudes and tendencies towards mathematics (Walker & Syed, 2013).

Out-of-School Mathematics Environments

These are the areas designated for out-of-school mathematics teaching and lessons. Outdoor classrooms may differ depending on variables such as the number of participants and budget. The aim is to create an outdoor classroom in which students can collaborate in out-of-classroom environments. Examples of out-of-school environments where school mathematics can be supported and what can be done in these environments are presented below.

Play: Mathematics teaching can be supported through games. To this end, games that can be played through materials can be used. For example, supportive activities can be carried out with educational play activities such as children performing arithmetic operations by using hands and feet, activities involving pattern cards, and teaching money and doing arithmetic by creating a shopping corner.

Brain Teasers: Brain teasers are materials that can be used to support mathematics learning in both in-school and out-of-school environments. Chess, sudoku, futoshiki, and puzzles are preferable teaching materials. Students' mathematical skills such as reasoning and problem solving are supported with these tools.

Technological Tools: Students are encouraged to practice their mathematical knowledge through interactive ways. Students interested in technology are provided with technology-supported mathematics activities. Weblogs, digital games, wikis, and podcasts are among the technological resources that can be used.

Travel/nature Activities: These are areas that provide natural and cultural richness. The state of mathematics in nature can be observed with field trips to school surroundings, national parks, and so on. Such nature activities and trips allow seeing the reflections of mathematics around us and noticing the exploratory aspect of mathematics besides the pure knowledge it embodies.

Museums: These are the areas where many works and documents inherited from the past to the present can be found. Museums vary in their content: science and technology museums, outdoor museums, archeology museums, history museums, military museums, private museums, etc. Within the context of mathematics education, science and technology museums make it possible to realize that mathematics is a cumulative science. They can provide information about the developments in the field of mathematics from the past to the present, the studies of scientists, and their contributions to the future.

Centers: These are units created for different contents and special areas. Among examples are science and technology centers and science and art centers, which display mathematics in practice. In this way, students have the opportunity to apply mathematics in out-of-school environments. Thus, a positive contribution is made to students' attitudes towards mathematics.

Industrial establishments: These are the places where tools, materials, and technological products involved in many areas of our lives are produced. The use of mathematics in working life and in the fields of industry and technology is exemplified and highlighted through trips to such establishments. The importance to be given by today's students who will be employed in important areas in the future to mathematics is increased through showing them how mathematics is used in lines of business.

Zoos: These are parks that are suitable for the living conditions of various animals. Zoos are convenient areas for the study of animal species. In these environments, students are allowed to practice arithmetic operations such as determining proportions in the food to be given to animals and the calculation of their weights. At the same time, the examples of mathematics in the structure of living things can be discovered through examination of animals and animal species.

Botanical Gardens: These are areas used for growing and studying plants. Thanks to the study of plants, the mathematical properties inherent in plants can be discovered. For example, mathematics in nature can be explored through practices such as the discovery of Fibonacci numbers in the outer shells of pinecones and pineapples and finding the golden ratio in the petals of flowers. Mathematics is associated with science thanks to these activities.

As out-of-school learning involves some out-of-school visits, it may be considered difficult to organize and afford them. In this regard, especially school grounds create an alternative for out-of-school learning and provide an easily accessible experience. In addition to being easily accessible and inexpensive, school grounds can also encourage students to develop a sense of ownership towards the school by providing them with a sense of belonging. In this respect, moving out-of-school practices to the school grounds can make out-of-school mathematical practices more applicable and easily accessible.

Below is a sample activity on data processing and analysis for out-of-school mathematics learning. The aim of the event is to set an example for educators and researchers on out-of-school mathematical practices.

Learning Domain:	Data Processing and Analysis
Target Group:	Elementary/middle school students
Aim:	-Drawing tables (tallies/frequency tables) and graphs (figures, column charts). -Reading the information in the table and making graphical transformation. -Reading and evaluating the information in the graph and performing addition and subtraction operations.

Skills:	-Predicting -Reasoning -Problem solving -Communication
Materials:	Fallen leaves Tree branches

Activity Steps

Introduction

Go to the forest area with students and create student groups of 3-5 people. Then address the following questions to the students:

- How many fallen leaves do you think there are in the forest?
- What colors can the fallen leaves be?
- Which colored leaves are more?

Then ask the students to make predictions and write their predictions on the worksheets. After that, explain the purpose of the activity and present the problem statement: “Let’s collect the fallen leaves in the forest and find answers to the questions that were just addressed.”

Collecting Data

Encourage the students to collaborate as a team and make sure that they share tasks such as collecting leaves and piling up the collected leaves. In this way, the students are encouraged both to observe the forest and to collect data for a specific purpose. After the leaf collection is completed, ask each group to group their leaves based on color (and/or size, type of leaf, etc.). Then repeat the questions asked at the beginning of the activity, make the students feel that grouping is not enough and a more detailed analysis is needed to find answers to these questions, and proceed to table-graph work. At this stage, emphasize that the raw data obtained by the students are not meaningful without the necessary statistical processes.

Creating Tables

The tables and graphs to be created can be used as figures/column tables and graphs in accordance with the student level. Ask the students to express the collected leaves as a table first. Frequency or tally table may be preferred at this stage.

Creating Graphs

Ask the students to interpret the data by looking at the tables they have created. Then make sure that they are transformed into graphic works for them to be easier to read visually.

Here, the aim is to improve the students' skills of creating tables, interpreting table data, transforming from tables into graphs, and reading graphs. Emphasize that graphs are tools that provide visual convenience in interpreting data. The numbers of leaves can be determined according to their colors by creating graphs through drawing or using the pieces of branch in the forest. At this stage, guide the students through making different graphic representations. Horizontal and vertical column chart or figure representations can be used. Show the advantages especially the column chart representation provides in data interpretation.

Evaluating and Interpreting Data

Address questions to the students in each group for them to evaluate the data.

- Which colored leaves are more/less?
- How many more leaves of which color are required for the numbers of leaves to be equal?
- Compare the leaves between your groups and determine the quantities.

You can integrate the concepts of arithmetic mean, maximum and minimum values, and range into the activity by deepening the data analysis in accordance with the student level. Ask the students whether different types of graphs can be used in the representation of the data and make them feel that different types of graphs such as pie charts and plots can also be used.

References

Baker, J. Y. (2007). *Out-of-school mathematics: Synthesis and analysis of research concerning the use of mathematics in non-school settings.* [Master's thesis]. Philadelphia: University of Pennsylvania.

Beard, C. (2006). *Experiential learning: A handbook of best practice for educators and trainers.* London: Kogan Page.

Bølling, M., Niclasen, J., Bentsen, P., & Nielsen, G. (2019). Association of education outside the classroom and pupils' psychosocial well-being: results from a school year implementation. *Journal of School Health, 89*(3), 210–218.

Bransford, J. D., Barron, B., Pea, R., Meltzoff, A., Kuhl, P. Bell, P., Stevens, R., Schwartz, D., Vye, N., Reeves, B., Roschelle, J., & Sabelli, N. (2006). Foundations and opportunities for an interdisciplinary science of learning. In K. Sawyer (Ed.), *The Cambridge handbook of the learning sciences*. Cambridge, UK: Cambridge University Press.

Bransford, J. D., Vye, N., Stevens, R., Kuhl, P., Schwartz, D., Bell, P., Meltzoff, A., Barron, B., Pea, R., Reeves, B., Roschelle, J., & Sabelli, N. (2006). Learning theories and education: Toward a decade of synergy. In P. Alexander & P. Winne (Eds.), *Handbook of educational psychology* (2nd Edition). Mahwah, NJ: Erlbaum.

Brooks, J. (2010). *The effectiveness of constructivist science ınstructional methods on middle school students' student achievement and motivation*. [PhD Dissertation]. Walden University.

Cherry, G. R. (2011). *Analysis of attitude and achievement using the 5E ınstructional model in an interactive television environment*. [PhD Dissertation]. Old Dominion University.

Cobb, P., Yackel, E., & Wood, T. (1992). A constructivist alternative to the representational view of mind in mathematics education', *Journal for Research in Mathematics Education*, *23*(1), 2-33.

Coombs, P. H., & Ahmed, M. (1974). *Attacking rural poverty: How non-formal education can help.* Baltimore and London: Johns Hopkins University Press.

Council for the Curriculum, Examinations Assessment (CCEA). (2007). *The Northern Ireland curriculum: Primary.* Belfast: CCEA.

Department for Education and Skills (DfES). (2006). *Learning outside the classroom manifesto*. Nottingham: DfES.

Duncan, G. J., Dowsett, C. J., Claessens, A., Magnuson, K., Huston, A. C., Klebanov, P.,… & Sexton, H. (2007). School readiness and later achievement. *Developmental Psychology, 43*(6), 1428–1446. doi:10.1037/0012-1649.43.6.1428.

Eshach, H. (2006). *Science literacy in primary schools and pre-schools.* Dordrecht, the Netherlands: Springer.

Eshach, H. (2007). Bridging ın-school and out-of-school learning: Formal, non-formal, and ınformal education. *Journal of Science Education and Technology, 16*, 171-190.

Fägerstam, E. (2014). High school teachers' experience of the educational potential of outdoor teaching and learning. *Journal of Adventure Education and Outdoor Learning, 14*(1), 56–81.

Fägerstam, E., & Samuelsson, J. (2014). Learning arithmetic outdoors in junior high school-influence on performance and self-regulating skills. *Education 3-13, 42*(4), 419–431.

Goldman, S. (2006). A new angle on families: Connecting the mathematics of life with school mathematics. *Counterpoints, 249*, 55-76.

Good, A. B., Burch, P., Stewart, M., Acosta, R., & Heinrich, C. (2014). Instruction matters: Lessons from a mixed-method evaluation of out-of school time tutoring under No Child Left Behind. *Teachers College Record*, *116*(3), 1-34.

Hoyles, C., Noss, R., & Pozzi, S. (2001). Proportional reasoning in nursing practice. *Journal for Research in Mathematics Education. 32*(1), 4-27.

Illich, I. (1970). *Deschooling society.* New York: Harper & Row.

Institute for Outdoor Learning (IOL). (2008). *What is outdoor learning?* Retrieved from http://www. outdoorlearning.org/what_is_outdoor_learning/index.htm.

Kendall, S., Murfield, J., Dillon, J., & Wilkin, A. (2006). *Education outside the classroom: Research to identify what training is offered by initial teacher training institutions*. Nottingham: DfES.

Livingstone, D. W. (1999). *The education-jobs gap: Underemployment or economic democracy.* Toronto: Garamond Press.

Mantzicopoulos, P., & Ala, S. (2013). Science literacy in school and home contexts: Kindergarteners' science achievement and motivation. *Cognition and Instruction, 31(1),* 62–119.

Martin, D. B. (2012). Learning mathematics while Black. *Educational Foundations*, *26*, 47–66.

Masingila, J. O. (2002). Examining students' perceptions of their everyday mathematics practice. In M. E. Brenner & J. N. Moschkovich (Eds.), *Journal for research in mathematics education: Everyday and academic mathematics in the classroom* (pp. 30–39). Reston, VA: The National Council of Teachers of Mathematics, Inc.

Ministry of National Education (MoNE). (2018). *Matematik dersi* öğretim *programı (*İlkokul *ve ortaokul 1, 2, 3, 4, 5, 6, 7 ve 8. sınıflar)* [Mathematics curriculum: Elementary and middle schools 3, 4, 5, 6, 7 and 8th grades)]. Ankara: Talim Terbiye Kurul Başkanlığı.

Mocker, D. W., & Spear, G. E. (1982). *Lifelong learning: formal, nonformal, informal, and self-directed.* Columbus: ERIC Clearinghouse on Adult, Career, and Vocational Education, The Ohio State University.

Moffett, P. V. (2011). Outdoor mathematics trails: an evaluation of one training partnership. *Education 3–13*, *39*(3), 277-287.

Pilz, M., & Wilmshöfer, S. (2015). Formal, nonformal, and informal learning in rural India: The case of fishing families on the Chilika Lagoon. *Prospects, 45(2), 231-243.*

Rea, T. (2008). Alternative visions of learning: Children's learning experiences in the outdoors. *Educational Futures: E-Journal of the British Education Studies Association, 1(*2), 42–50.

Resnick, L. (1987). Learning in school and out. *Educational Researcher, 16*(9), 13–20.

Rickinson, M., Dillon, J., Teamey, K., Morris, M., Choi, M. Y., Sanders, D., & Benefield, P. (2004). *A review of research on outdoor learning: Executive summary*. Field Studies Council, Shrewsbury. Retrieved from https://www.informalscience.org/sites/default/files/ Review%20of%20research%20on%20outdoor%20learning.pdf

Rivkin, M. S. (2000). *Outdoor experiences for young children.* ERIC Digest. Charleston, WV: ERIC Clearinghouse on Rural Education and Small Schools.

Schliemann, A. D., & Acioly, N. M. (1989). Mathematical knowledge developed at work: The contribution of practice versus the contribution of schooling. *Cognition and Instruction, 6*(3), 185-221.

Schoenfeld, A. H. (1989). Problem solving in context(s). In R.I. Charles & E.A. Silver (Eds.), *The teaching and assessing of mathematical problem solving* (pp. 82-92). Hillsdale, NJ: Lawrence Erlbaum Associates.

Scribner, S. (1984). Studying work intelligence. In J. Lave & B. Rogoff (Eds.), *Everyday cognition: Its development in social context,* (pp. 9-40). Cambridge, MA: Harvard University Press.

Tal, T., & Morag, O. (2009). Reflective practice as a means for preparing to teach outdoors in an ecological garden. *Journal of Science Teacher Education, 20*, 245-262.

Tan, E. (2010). *Participatory and critical out-of-school learning for urban youth: building community through popular culture*. [PhD Dissertation]. McGill University, Montreal.

Unlu, A., & Dettweiler, U. (2015). Motivation internalization and simplex structure on self-determination theory. *Psychological Reports: Employment Psychology & Marketing, 3,* 675–691.

Waite, S. (2007). Memories are made of this: Some reflections on outdoor learning and recall. *Education 3–13 , 35*(4), 333–47.

Waite, S. (2011). Teaching and learning outside the classroom: Personal values, alternative pedagogies and standards. *Education 3-13, 39*(1), 65–82.

Waite, S., & Rea, T. (2007). Enjoying teaching and learning outside the classroom. In D. Hayes (Ed.), *Joyful teaching and learning in the primary school* (pp. 52–62). Exeter: Learning Matters.

Walker, E. N. (2012). Cultivating mathematics identities in and out of school and in between. *Journal of Urban Mathematics Education*, *5*(1), 66–83.

Walker, L. H. M., & Syed, M. (2013). Integrating identities: Ethnic and academic identities among diverse college students. *Teachers College Record*, *115*, 1–24.

SECTION 3
SCIENCE EDUCATION

Science Teaching Environments in Early Childhood Education

Mehmet Mart

Necmettin Erbakan University

"Science in early childhood is of great importance for the development of children's scientific concepts as well as for many other aspects of their development" (Kallery & Psillos, 2002, p. 50). Besides this, science is the part of life to understand the world better, so children start learning and practising the scientific concepts during the preschool age (Charlesworth & Lind, 2010). Therefore, having scientific knowledge of the world around us is important and it is formed since birth. Children's first touches at homes are their initial experiences of science around them, for example; understanding of day and night, cooking, planting and so on. The activities are led by parents and playing prepares children to understand the world and increases the children's readiness for formal learning. This is because daily activities in preschool education constitute the basis of science education (Önal & Sarıbaş, 2019).

Science activities are one of the required activities in early childhood education during daily activities. Daily routine activities in Turkey are identified by Preschool Education Programme, which are language (Turkish), art, drama, music, movement, play, science, math, preparation for literacy and field trips (Milli Eğitim Bakanlığı, 2013). Science is mentioned two different types: the science centre and science activities. While arranging classrooms with some centres (block, drama, art, book, science, sand and water, and music centres) in preschool, there are also some activities: language (Turkish), art, drama, music, movement, game, science, math, preparation for literacy, and field trips (Milli Eğitim Bakanlığı, 2013). These centres and activities are ideally recommended by Ministry of National Education as a preschool education programme in 2013, and teachers are required to follow this programme in their activities. As can be seen from the programme, science is given importance in both centres and activities. However, science activities are neglected as a result of lack of time (Charlesworth & Lind, 2010). In this case, Alisinanoğlu, Özbey and Kahveci (2007) underline that there is no requirement for expensive and various materials in early childhood education, children can get confronted with science via basic methods, inexpensive materials and enhanced learning environments. This means that science activities can be provided to children without any special requirements, and the existing facilities and opportunities can be used to conduct various science activities.

To conduct activities, teachers have the responsibilities to achieve such aims. However, the role of teachers is to ensure a wide range of opportunities for children to explore, experiment and discover in different learning environments such as indoors and outdoors (Bose, Tsamaase, & Seetso, 2013). Within science activities, children's active participation to experiments, their observations to scientific aspects and attending the nature trips enable developing children's various skills like comparison, classification, identifying relationships, attention, observation, experimentation, hypothesising skills (Ayvacı, Devecioğlu, & Yiğit, 2002; Önal & Sarıbaş, 2019). Correspondingly, such skills can be enhanced by having experiments and exploring the environments as science activities (Akyol & Birinci Konur, 2018). In this case, various areas should be used to fulfil the requirements for science activities.

Therefore, it is important to provide a clear understanding of the context of schools to have an exact overview of the science teaching environments. In this case, the following aspects will be identified: classroom activities, outdoor activities, school grounds and field trips.

Science in Classrooms

One of the significant places for activities is the classroom, and teachers' primary preferences are classrooms for the activities. Indeed, the classroom is the first context when we think about school. This approach influences the case of science in the early years. Above-mentioned science centre and activities are subject to be practised in the classroom, and science is served in two ways: science centre and science activities. The example of an ideal classroom from the preschool education programme illustrates the necessary centres in a classroom, and number 5 shows the science centre. This is because the quality of the classroom and children's experience have a parallel relationship (Shim, Herwig, & Shelley, 2001). Furthermore, "the classroom environment needs to have comfortable and modifiable features according to the children's interests" (Dogan & Simsar, 2018, p. 72).

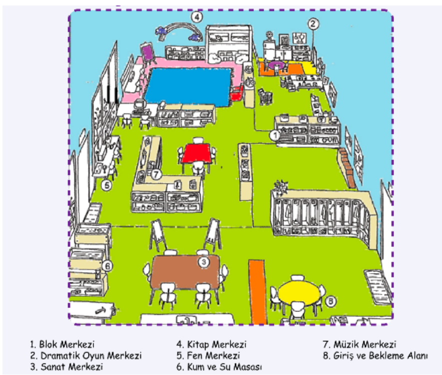


Image 1: Ideal Classroom Design

As it is an important part of a classroom, science centres are stimulant areas for children in terms of providing opportunities for experiments and observation (Önal & Sarıbaş, 2019). Additionally, science centres are required to be located in a place sun-soaked, to be enriched with closets and shelves, and to have easy access to the garden (Simsar, Doğan, & Yalçın, 2017). Image 2 shows an example of a school in Turkey. Although there is a list of must-have characteristic for the science centre in schools, this example shows the inadequacy of required arrangements for the centre. This example illustrates the overall context of Turkey. While the preschool education programme emphasises the importance of science centres in schools which have enough spaces to create, schools have no/or insufficient science materials.

Image 2: A Classroom Example from Turkey

In this example, there is only a globe, artificial tree, scales, cones and experiment materials (three different colours in bottles and an agitation vessel). When the ideal classroom can be arranged in this space (as there is a wide scope), some materials such as natural materials and artificial science materials are put in a randomly selected place as a science centre in general.

Science should be promoted by both materials at the science centre and science activities through the daily routine activities in the early years. Science activity is the less preferred activity in daily activities. This is because, in the practice, there are always considerable differences between expected practices in classrooms and actual practices because of not having standardised opportunities in the classroom for science activities (Kallery & Psillos, 2002). For a science activity, teachers need to consider the activity in advance and to design in advance. Therefore, teachers might avoid conducting science activities on a daily basis. In terms of having a determined procedure, in Akyol and Brinci Konur's (2018) research, teachers' practices show that they mostly conduct experiments during their daily activities because of having experiments as a part of ordinary activities. This is because experiments are arisen as key activities to achieve learning outcomes for science activities (Gezgin & Kılıç, 2015). Image 3 shows an activity that children build a rocket. From the teacher's reflection, it is a part of a list of combined activities that it is part of watching a documentary about rockets and space, then she let children constitute rockets from the materials in the classroom.

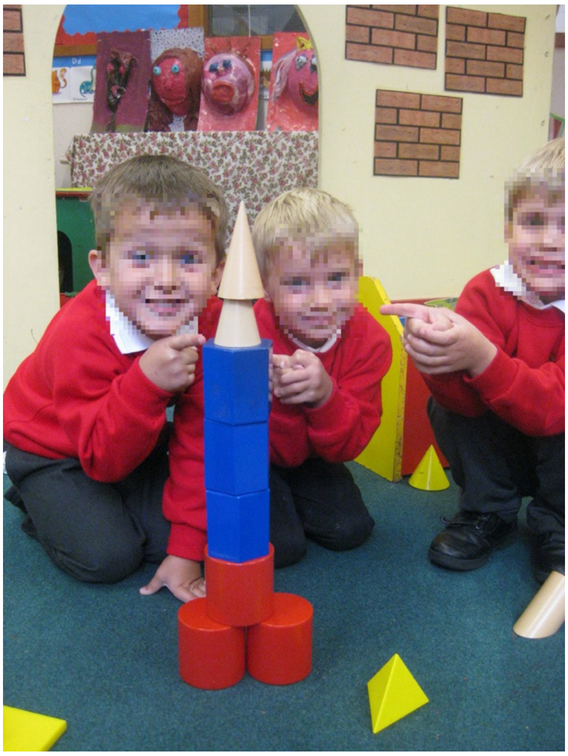


Image 3: A Science Example from England

Image 4 and 5 are from a kindergarten in Turkey. Both images are from science activities.

Image 4: A Science Example from Turkey (Making Cupcake)

Image 5: A Science Example from Turkey (Olive Making)

Image 4 is ‘making a cupcake’ and image 5 is ‘olive making’. In both examples, the teacher planned the activities before the activity days and prepared the required tools and materials in advance. For the example of image 4 illustrating, the teacher needs to check the ingredients for the cake and bought them considering the number of children with an arrangement of the classroom space. In the example of image 5, the teacher decided to have pickling as an activity. Therefore, s/he had to consider the season for this and the required vegetables. As it can be seen from image 5, the teacher prepared vegetables, vessels for cooperation etc., so children all can sit down to ground together as a big circle and can perform the necessary steps for pickling.

Parallel to given examples, mostly experiments and direct instructions were used, and teachers rarely considered implementing various methods as science activities (Dağlı & Dağlıoğlu, 2020). This is because teachers have feelings be competent for experiments, but they have unfavourable notion to develop materials for science (Dogan & Simsar, 2018). Teachers keen to use kitchen activities, experiments and watching documentaries as science activities, but the only small number of teachers uses the techniques: collection, identifying tools and using them and so on (Çınar, 2013). In this case, the classroom has objectives to be fulfilled in terms of science, but the practical part is different than the expected. Classrooms are the key areas to conduct science activities as it is the main place.

Science in Outdoors

Outdoor areas cover various aspects such as school grounds, parks, gardens and so on. As the classroom is mentioned as the key component for science activities as well as accommodating science centre, outdoor areas are likely to ensure the same opportunities. Thus, outdoors are considered by schools to have equal to or more important than indoor (Malone & Tranter, 2003). “The outdoor playground offered older preschoolers particular types of play experiences (i.e., functional play and dramatic play) more readily than the classroom” (Shim et al., 2001, p. 149). In preschool education programme, all types of activities, structured, semi-structured or unstructured activities, can be also conducted in outdoors like in the classroom (Milli Eğitim Bakanlığı, 2013). As there is no accurate requirement for outdoor activities, the statements in the programme emphasise it a few times as an additional area for children to have various activities. Alat et al. (2012), therefore, claims that some of the participating teachers in their research perform activities outside in addition to the classroom without needing a determination and requirement by the curriculum. In this case, Kermani and Aldemir underline that “… implementing a robust early childhood education curriculum focusing on math, science, and technology could bring a positive change in children’s overall learning of math, science, and technology as well as in teachers’ attitudes and ability to plan an integrated curriculum for young children” (2015, p. 1522).

Image 6: An English School's Outdoor Area

In terms of science, the science centre (and other learning centres) can be organised outside of the classroom as well, and science activities can be conducted in various ways to the contrary of the classroom. Image 6, from an English School, is an example of how outdoor area is connected to the school building as well as what how it could be. In image 6, the photo was taken in front of kindergarten’s door to the outdoor area, and there is a path to a wide outdoor area. In this outdoor area, there are lots of materials and loose parts which can be used for science activities, and it is also close to nature, so various scientific process abilities: observation, classification, communication, measurement, prediction, deduction and comparison (Güneş, 2018; Murray, 2019; Önal & Sarıbaş, 2019) can be gained in well-designed outdoor areas. Çınar’s (2013) finding of collecting flowers from school ground and examining their leaves, roots and bodies in the classroom can be smoothly accomplished in outdoor areas.

Image 7: An Outdoor Activity Area in Turkey

In previous research, teachers underlined the difficulties with practising science activities in classrooms, so teachers have dispositions to have such activities mostly outside (Bose et al., 2013). Sağlam and Aral's (2015) research indicates that science activities are perceived by children as interesting because of having used various, new and stimulus materials as well as natural and authentic. This is because science activities in outdoor provide scientific skills, "resilience, perseverance and confidence" (Murray, 2019, p. 219). Out of the classroom is furthermore mentioned with enjoyment and play via promoting child-led activities and learning (Maynard, Waters, & Clement, 2013).

However, there is likely to occur some problems with conducting outdoor activities. In this case, outdoor activities for science brings some drawbacks with it, and there are some bureaucratic challenges, insufficient materials and environments, economic issues and so on. (Türkmen, 2015). Image 7 shows an average school in Turkey. It can be seen that school ground is used for car parking, there is a few trees on the edge of the school ground and there is a small park with slide, teeter-totters etc. The ground of the park is soil and other places are surrounded by a concrete surface. It should be mentioned that the typical school grounds in Turkey is used for car parking, and children are needed to play among the cars. Önal and Sarıbaş (2019) found out that just over half of participating teachers claimed the inadequate school garden and outdoor areas for science activities.

Recently, the importance of outdoor areas has been increasing in various early years programmes to provide children to have regular access to natural grounds like "…the bush, the beach, local parks, creeks or botanical gardens, etc." (Christiansen, Hannan, Anderson, Coxon, & Fargher, 2018, p. 64). Other research shows that some activities are conducted outside in addition to indoor so that children's active participation can be employed; children can learn how to use science centre on their own as well as promoting a positive approach to science, and children's observation and interpretation skills can be developed in outdoors, but teachers had no endeavour to provide such outdoor opportunities (Ayvacı et al., 2002, p. 19). To support outdoor activities, teachers have various opportunities to conduct. These are; school grounds and field trips (which are commonly used in Turkey).

Science in School Grounds

One of the most used outdoor areas is school grounds, which are easily accessible for all early years teachers. Apart from the general concept of outdoor areas, school grounds consist of limited space within the area surrounding the building to identify the land of schools. As a basic activity which can be conducted school grounds, plant breeding can enable children to learn about types of soils and plant species (Önal & Sarıbaş, 2019). This is parallel to Sağlam and Aral's (2015) findings that children find a chance to check, to measure the growth of and to irrigate onions, which were planted in the school garden.

“Schoolgrounds have potential as a rich resource for formal learning” (Malone & Tranter, 2003, p. 94). Alat et al. (2012) claim that teachers are a key component to implement activities in school gardens because they can make arrangements as is required.

In the consideration of the requirement of hands-on learning, which is enhanced by observations, the importance of having well-designed school grounds are the best places to be considered to fulfil the aims (Karamustafaoğlu & Kandaz, 2006). For instance, image 8 shows a school ground from England. In this small space, it can be seen that there are water trays, wooden logs, a water tank and lines etc. These materials are designed to serve as a science centre and activity. As can be seen, the science centre can be constituted, and science activities can be performed although the space is limited.

Image 8: A School Ground from England

The most significant problem with using school grounds is that early years settings have no separated garden for themselves, and if they are part of primary schools, they, early years settings and primary schools, are obliged to share the same school gardens so that the use of school garden is limited (Alat et al., 2012; Mart, Alisinanoğlu, & Kesicioğlu, 2015). Parallel to these statements, image 9 demonstrates a typical example of the Turkish context. Overall schools have similar school grounds that the surface is covered with tarmac, so children need to play/do activities in this tarmac grounds.

Image 9: A School Ground in Turkey

In addition to this, there is no separate school ground for most of the kindergartens as being part of primary or secondary schools. While kindergarten is a younger age group only, various age groups can be on the playground at the same time (Shim et al., 2001). Even if the school is a nursery, “there often were two or three other classrooms of children on the playground at the same time” (Hirose, Koda, & Minami, 2012, p. 1614). In this shown activity, play and science activities are combined that while children are learning about capacity, they need to compete with others. The whole classroom separated two groups, and each group tries to fill the container with carrying water with cups. Though there is no specifically arranged school ground and materials for early years children, they are using common school ground for their activities. Correspondingly, previous research underlines the inadequacy of school grounds for preschool-age children (Karamustafaoğlu & Kandaz, 2006). Another example from the English context, image 10 indicates a similar inadequacy for the early years. In this example, school ground is used to arrange a science centre for children to play. Given that there is a small sand area with animal figures on it. Within this constraint, children still find chances to understand the animal kingdom.

Image 10: A School Ground in England

However, the fact is that although all schools have some extend school grounds, only half of them has school gardens, and most of these gardens was dominated by weeds, natural habitats and decoration plants. The participating teachers used school gardens for various activities such as science, movement, play and so on (Orçan Kaçan, Halmatov, & Kartaltepe, 2017). Image 11 shows a different example from the Turkish context. This kindergarten has a separated ground for them, and it is soil. The ground has been left unintended, so there are lumps and a few trees around the ground. In the seen activity, children are digging the ground to find worms and various insects. As it is hard to dig when it is dry, the teacher added some water to make it funnier. It can be seen that children are playing together and doing their activities. This area could also be used for plating. This is because one of the basic activities at school grounds is plant breeding and this activity enables children learning about soil/ground as well as contributing to learning plant species etc. (Önal & Sarıbaş, 2019). In addition to this, children can find chances to have a close relationship with living things so that can have sensory experiences (Çelik, 2012).

Image 11: A School Ground in Turkey

Sum up, school grounds can be limited but there could be provided lots of opportunities for children, there is no obligation to have a rich environment and materials. Any types of school grounds can be used to enhance the quality of science activities with planning.

Science in Field Trips

Field trips are mentioned as a type of activity in preschool education programme (Milli Eğitim Bakanlığı, 2013), but it is also an important learning adventure for science activities, and it is named under one of the science activities (Alisinanoğlu et al., 2007). Field trips support children's developments as well as provide real-life experiences so that children learn about social convections through field trips (Önal & Sarıbaş, 2019). "Children can learn about adult roles through field trips to businesses such as restaurants, banks, the post office, and stores both in the local neighbourhood and in the extended community. Museums, construction sites, hospitals, fire stations, and other places offer experiences that can enrich children's knowledge of adult roles" (Charlesworth & Lind, 2010, p. 307).

Field trips are connected with observation skills, so that observation is based on viewing human-beings, animals, plants and some events in their natural environment (Önal & Sarıbaş, 2019). Image 12 is from a visit to the museum of Atatürk's House. It can be seen that children are observing some objects displayed. This enables them to understand the history and cultural backgrounds as well as to recognise the meaning and effect of time in terms of scientific aspect. To achieve the aims of the field trips, teachers need to ask questions to provoke children's interest as well as providing observation opportunities via using their sensations (Alisinanoğlu et al., 2007).

Image 12: A School Visit to Museum

In previous research, field trips are considered as a high-quality method to teach science, but the participating teachers had a lack of knowledge on how to process field trips within their aims (Türkmen, 2015). Correspondingly, the reasons for avoiding to emphasise the importance of field trips are likely to occur because of the limitation of physical facilities or having a feeling of inadequacy (Akyol & Birinci Konur, 2018). In this case, teachers are required to be well-planned and prepared before the field trip. Image 13 shows a visit to the science centre, and a group of children is trying a simulation machine. Field trips are the best ways to provide first-hand experiences for children to learn about the context and provide a wide range of opportunities for teachers to promote learning that children can be asked to draw a type of material/object etc. (which will be seen at the science centre) before and after the trip, then they are asked to compare their both drawings so that teachers can raise a discussion on similarities and differences between the drawings (Charlesworth & Lind, 2010). Thus, children can compare their imagination and actual events/objects by themselves.

Image 13: A School Visit to Science Centre

Even though field trips provide a wide range of opportunities, there is likely to escalate some issues by stakeholders. It is claimed that having problems with transportation and handling with procedures make trips difficult for teachers and directors (Akyol & Birinci Konur, 2018). However, such problems and difficulties can be overcome for children not to miss the benefits of field trips to develop scientific abilities.

References

Akyol, N., & Birinci Konur, K. (2018). Okul Öncesi Dönemde Fen Eğitiminin Uygulanabilirliğine Yönelik Öğretmen ve Yönetici Görüşlerinin İncelenmesi.

Kastamonu Eğitim Dergisi, 26(2), 547–557. https://doi.org/10.24106/kefdergi.389823

Alat, Z., Akgümüş, Ö., & Cavalı, D. (2012). Okul Öncesi Eğitimde Açık Hava Etkinliklerine Yönelik Öğretmen Görüş ve Uygulamaları. *Mersin Üniversitesi Eğitim Fakültesi Dergisi, 8*(3), 47–62. https://doi.org/10.17860/efd.49967

Alisinanoğlu, F., Özbey, S., & Kahveci, G. (2007). *Okul öncesinde fen eğitimi*. Ankara: Nobel Kitabevi.

Ayvacı, H. Ş., Devecioğlu, Y., & Yiğit, N. (2002). Okul öncesi öğretmenlerinin fen ve doğa etkinliklerindeki yeterliliklerinin belirlenmesi. *V. Ulusal Fen Bilimleri ve Matematik Eğitimi Kongresi Bildiriler Kitabı*, (pp. 16-18). Retrieved from https://d1wqtxts1xzle7.cloudfront.net/4751484/t277d.pdf?response-content-disposition=inline%3B+filename%3DOKUL_ONCESI_OGRETMENLERININ_FEN_VE_DOGA.pdf&Expires=1608808004&Signature=CRcgHM~N8lnEkMHTplz8wU4DRCSkXEGsrVeBD3-WtmS3K835afgvP0OwSScnaIVD7BXhFh9Z9qgxfCpRL9IVo1hxJba5Mt4aQp4N6gBPlgQhQ4UN27BV9jKWtVDP541SzVvewPE4p0xRqvlctpxCuIz8FyGXz1301CVzBT9zVvu1siisrxvSFC9c3nNbc0fqkXt2jZIk-vDpDRedf38zT6Wrqehd1IJIEg0Ylegt-cWHw8Zz7ikfPSQoAyH4Xsjf3p6zY83WD7sN-gW4tAmZ8jMWUdQ9sWRDhNAh4gfhoZ1IEaLPNLWuiKpE3wUtbydJnIMkp4QYYSUTuXdjcmSEg__&Key-Pair-Id=APKAJLOHF5GGSLRBV4ZA

Bose, K., Tsamaase, M., & Seetso, G. (2013). Teaching of Science and Mathematics in Pre-Schools of Botswana: The Existing Practices. Creative Education, 4(7), 43–51. https://doi.org/10.4236/ce.2013.47a1006

Çelik, A. (2012). Okul Öncesi Eğitim Kurumlarında Açık Alan Kullanımı: Kocaeli Örneği. *Atatürk Üniversitesi Ziraat Fakültesi Dergisi, 43*(1), 79–88. https://doi.org/10.17097/zfd.95656

Charlesworth, R., & Lind, K. K. (2010). *Math and Science for Young Children* (6th ed.). Belmont: Cengage Learning.

Christiansen, A., Hannan, S., Anderson, K., Coxon, L., & Fargher, D. (2018). Place-based nature kindergarten in Victoria, Australia: No tools, no toys, no art supplies. *Journal of Outdoor and Environmental Education, 21*(1), 61–75. https://doi.org/10.1007/s42322-017-0001-6

Çınar, S. (2013). Okul Öncesi Öğretmenlerinin Fen ve Doğa Konularının Öğretiminde Kullandıkları Etkinliklerin Belirlenmesi. *Eğitim ve Öğretim Araştırmaları Dergisi, 2*(1), 364–371.

Dağlı, H., & Dağlıoğlu, H. E. (2020). Okul Öncesi Öğretmenlerinin Fen Eğitiminin İçeriği ve Standartlarına İlişkin Görüşlerinin İncelenmesi. *OPUS Uluslararası Toplum Araştırmaları Dergisi, 15*(23), 125–144. https://doi.org/10.26466/opus.631378

Dogan, Y., & Simsar, A. (2018). Preschool Teachers' Views on Science Education, the Methods They Use, Science Activities, and the Problems They Face. *International Journal of Progressive Education, 14*(5), 57–76.

Gezgin, D., & Kılıç, D. (2015). Okul Öncesi Öğretmenlerinin Fen Etkinliklerinde Tercih Ettikleri Kazanım ve Yöntemlerin Belirlenmesi. *Mersin Üniversitesi Eğitim Fakültesi Dergisi, 11*(3), 620–630. https://doi.org/10.17860/efd.46048

Güneş, G. (2018). Okul öncesi fen ve doğa eğitimi araştırmalarına ilişkin bir tarama çalışması: Türkiye örneği. *Erken Çocukluk Çalışmaları Dergisi, 2*(1), 1–35.

Hirose, T., Koda, N., & Minami, T. (2012). Correspondence between children's indoor and outdoor play in Japanese preschool daily life. *Early Child Development and Care, 182*(12), 1611–1622. https://doi.org/10.1080/03004430.2011.634065

Kallery, M., & Psillos, D. (2002). What happens in the early years science classroom? *European Early Childhood Education Research Journal, 10*(2), 49–61. https://doi.org/10.1080/13502930285208951

Karamustafaoğlu, S., & Kandaz, U. (2006). Okul Öncesi Eğitimde Fen Etkinliklerinde Kullanılan Öğretim Yöntemleri ve Karşılaşılan Güçlükler. *Gazi Üniversitesi Gazi Eğitim Fakültesi Dergisi, 26*(1), 65–81. https://doi.org/10.17152/gefd.49987

Kermani, H., & Aldemir, J. (2015). Preparing children for success: integrating science, math, and technology in early childhood classroom. *Early Child Development and Care, 185*(9), 1504–1527. https://doi.org/10.1080/03004430.2015.1007371

Malone, K., & Tranter, P. (2003). Children's Environmental Learning and the Use, Design and Management of Schoolgrounds. *Children Youth and Environments, 13*(2), 87–137.

Mart, M., Alisinanoğlu, F., & Kesicioğlu, O. S. (2015). An Investigation of Preschool Teachers Use of School Gardens in Turkey. *The Journal of International Social Research, 8*(38), 721–727. https://doi.org/10.17719/jisr.20153813683

Maynard, T., Waters, J., & Clement, J. (2013). Child-initiated learning, the outdoor environment and the "underachieving" child. *Early Years: An International Research Journal, 33*(3), 212–225. https://doi.org/10.1080/09575146.2013.771152

Milli Eğitim Bakanlığı. (2013). *Okul Öncesi Eğitim Programı* (Preschool Education Programme). Retrieved from http://tegm.meb.gov.tr/dosya/okuloncesi/ooproram.pdf

Murray, J. (2019). Routes to STEM: nurturing Science, Technology, Engineering and Mathematics in early years education. *International Journal of Early Years Education, 27*(3), 219–221.

Önal, T. K., & Sarıbaş, D. (2019). Okul Öncesi Dönemde Fen Eğitimi ve Önemi. *Uluslararası Karamanoğlu Mehmetbey Eğitim Araştırmaları Dergisi, 1*(2), 109–118.

Orçan Kaçan, M., Halmatov, M., & Kartaltepe, O. (2017). Okul öncesi eğitim kurumları bahçelerinin incelenmesi. *Erken Çocukluk Çalışmaları Dergisi, 1*(1), 60–70. https://doi.org/10.24130/eccd-jecs.196720171112

Sağlam, M., & Aral, N. (2015). The Study of Determine Pre-School Teachers' Ideas About Science Education. *İnönü Üniversitesi Eğitim Fakültesi Dergisi, 16*(3), 87–102. https://doi.org/10.17679/iuefd.16308213

Shim, S.-Y., Herwig, J. E., & Shelley, M. (2001). Preschoolers' Play Behaviors with Peers in Classroom and Playground Settings. J*ournal of Research in Childhood Education, 15*(2), 149–163. https://doi.org/10.1080/02568540109594956

Simsar, A., Doğan, Y., & Yalçın, V. (2017). Okul Öncesi Sınıflarındaki Fen Merkezleri ve Kullanım Durumlarının İncelenmesi-Kilis Örneği. Sosyal Bilimler Dergisi, 7(14), 147–164.

Türkmen, H. (2015). Primary Teachers Point of View about Science Teaching In Outdoor Learning Environments [İlkokul Öğretmenlerin Sınıf Dışı Ortamlardaki Fen Öğretimine Bakış Açıları]. *Journal of European Education, 5*(2), 47–55.

New Trends in Science Education within the 21st Century Skills Perspective

Sahin Idin

The Scientific and Technological Research Council of Turkey

Introduction

Today, we are facing more problems in real world that we live. These problems can be illustrated such as climate change, new terminal diseases, natural disasters and so on. To be able to solve those mentioned problems we must firstly know our World. Science and science education makes this possible for people. Human meets science when he/she is born. At that time his/her lungs fill with Oxygen and starts to cry. As it can be understood from this scientific event we are not strangers to science. Herein a question is very significant to be learnt science in 21st century. Many indications show us students science knowledge's level. For instance Programme for International Student Assessment (PISA) and Trends in International Mathematics and Science Study (TIMSS) results give us deep information about countries' level in the scope of science education. The PISA examines what students know in reading, mathematics and science, and what they can do with what they know. OECD (2019), science score mean is 489 in PISA 2018. According to the results is found in 2018 PISA shows us that 14 OECD countries' science scores mean is under OECD average. While some countries are successful in science education, most are not. TIMSS (2015), science achievement results are reported as average scores and distributions on the fourth and eighth grade science achievement scales. Within this context, 33 countries' science score means is under 500 (centerpoint) for fourth grade among 47 countries and 20 countries' science score means is under 500 (centerpoint) for eight grade among 47 countries. The most important questions which should be answered is that are ~~our~~ schools adequately prepared to educate students for future challenges? Besides this it can be argued that many students are not able to access to high quality science education they need. Becuase during Covid pandemic crises many students are not able to Access to face to face education. United Nation (2020), the Covid-19 pandemic created the largest disruption of education systems in history, affecting nearly 1.6 billion students in more than 190 countries. Closures of schools impacted 94 per-cent of the world's student population, up to 99 per cent in low and lower-middle income countries. It implies many students from both poor and developing countries can not acess to the educaion. This result show us the importance of 21st century teaching tools for successful science education. With the effect of technology and engineering science is making progress everyday.

21st Century Skills and Science Education

Education systems have been changin in accordance with the changes in science and its disciplines. The Partnership for 21st Century Skills (2011), defines 21st century's skills as criticial thinking, collaborating, communication, and creativity. National Research Council (2010), defines as they are nonroutine problem solving, self-development, systematic thinking, adaptability and complex communication skills. İdin (2018), adds innovation, employability and efficient team working within the scope of 21st century's skills.

Today, we have been talking about Industry 4.0. and it can be thought as smart industry since its philosophy. İdin (2018), its elements are big data and analytics, autonomous robots, simulation, horizontal vertical system integration, additive manufacturing, augmented reality, the cloud, the industrial internet of things and cyber-security. These elements are seen that they are directly related to technology and to be able to achieve succsess in those fields 21st century skills are mcu more paid attention. World Economic Forum (2020a), states that technological change is happening faster than before. According to a research if it is right, in 2022 while the rate of automation looks like 42% (human workforce will be %58) and in in 2025 it will be 52% (human workforce will be %48) of total workforce.

Saavedra & Opfer (2012), summarize the science of learning as it relates to teaching and learning 21st century skills and suggested general courses that other education systems may apply to move toward similar outcomes. These are *make it relevant, teach through the disciplines, simultaneously develop lower- and higher-order thinking skills, encourage transfer of learning, teach students to learn to learn, address misunderstandings directly, understand that teamwork is an outcome and promotes learning, exploit technology to support learning and foster students' creativity.*

World Economic Forum (2020b), states that there have been similarities across industries when looking at increasingly strategic and increasingly redundant job roles. It also estimates that by 2025, 85 million jobs might be displaced by a change in the division of labour between humans and machines. 97 million new roles may emerge that are more adapted to the new division of labour between humans, machines and algorithms. It is also seen that those given jobs are directly related with Industry 4.0 fields and STEM, as well. Those given jobs are needed to work in collaboration efficiently when a problem occurs. In a efficient team working it is able to create a solution of a problem. Because it is not so easy to find a solution by a just person in 21st century. Systems, machines, content of them are not simple today. These reasons take us to think much more about 21st century skills.

Efficient Science Teaching and Learning Methods within Trends in 21st Century

There have been using some kind of educational teaching and learning methods and techniqs. Four of them is given here: Problem solving based learning, Project based learning, Inquiry based learning and STEM Education. Kyza et al (2014) state that there has been widely distributed interest in the development of innovative inquiry learning materials to answer to societal demands and improve the learning of science. Lin, Lin, Potvin & Tsai (2019) revealed that STEM Education is one of gradually emphasised educational approaches.

Problem Solving Based Learning: One of the most significant method is Problem solving Based Learning Approach which is first applied in case W. University Medical Shool in US in the 1950s. Aydoğdu (2003) Then, nearly thirty years ago, it was started to be practiced in a remarkablem few medical schools. Problem-solving learning constitutes one of the most important applications of constructivist learning environments. It is thought as a strong classroom process that motivates students in defining the problem, directs them to research concepts, provides a collaborative work environment, increases communication skills, uses real-world problems, and a strategy that supports lifelong learning habits. Problem-based teaching strategy; It is a whole that includes educational strategies that include problem solving, research and event-based learning. The important thing in all of these different strategies is that students who are in the process of answering some questions and solving some problems are successful.

Project Based Learning: Project Based Learning (PBL) is a typical of collaborative, inquiry-based learning, engagement of students and PBL enables students work together ro resolve a given problem create a product and later assess both Project output and the process (Loyens, Kirschner & Paas, 2010; Kokotsaki, Menzies & Wiggins, 2016; Thomas, 2000, Tsybulsky & Muchnik- Rozanov, 2019).

Inquiry Based Learning; Some terms are used to identif inquiry based learning including enquiry-based learning, guided-inquiry, problem- based learning, undergraduate research and research-based teaching Spronken-Smith & Walker (2010). The basic content of an inquiry based learning approach can be given below (e.g. Justice et al. 2007; Kahn and O'Rourke 2004; Weaver 1989): Learning is stimulated bu inquiry, student centered, active research and involving learning by doing, learning is supported by previous learning and a move to self-directed learninn with learners having more responsibility for their learning process.

STEM Education; STEM education has been mentioned since 2000s first ten years. It is seen that there can be given some STEM explanations. Gonzales and Kuenzi (2012), states that the term (STEM Education) refers to teaching and learning in the fields of science, technology, engineering, and mathematics. Isabelle and Valle (2016) state that

STEM are viewed as separate domains of knowledge, connected together mainly for the role they play in the job market of the 21st century global world.

Akerson (2018) states that teachers would need to know the natures of the disciplines they are to teach. But if they haven't been successful in the past in helping teachers better conceptualize nature of science, as well as teach it, how can we help them better conceptualize all four disciplines, plus the connections among them, and then teach these ideas to students? These points are cticital to teach STEM to the students.

At thi point, Bybee's (2013) some suggestions of STEM definition can be seen which are given below:

- Knowledge, attitudes, and skills to identify questions and real World problems and to explain evidence-based results about STEM based issues.
- Understanding of the fundamental features of STEM disciplines
- Awareness of how STEM disciplines shape our material, intellectual, and cultural environments
- Voluntarily engage in STEM issues in accordance with 21st centruy skills.

It is necessary to mention the relationship between STEM Education and twenty-first century skills in revealing the future of science education. The relationship between STEM Education and 21st century skills is given in a model created by İdin (2018) at Figure 1.

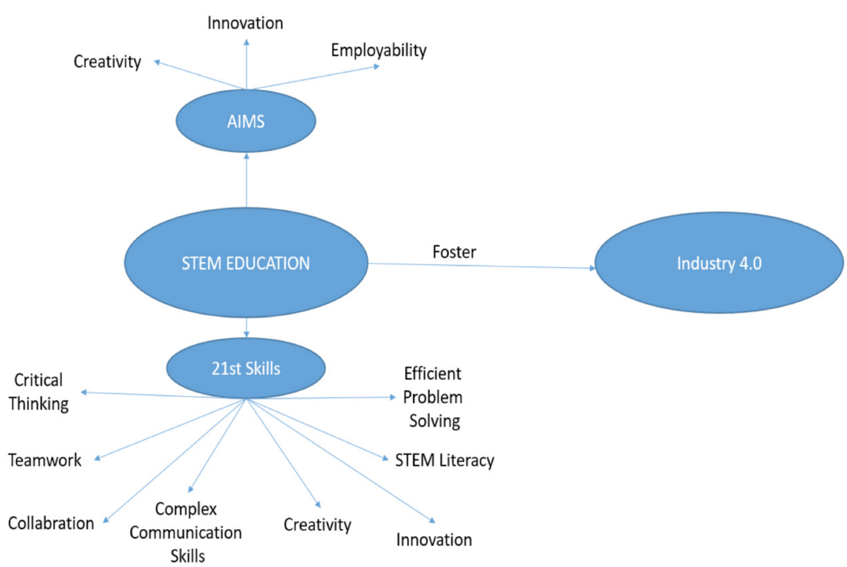


Figure 1. The relationship between STEM Education and 21st Century Skills

In the model, it can easily be seen that STEM Education and 21st century skills are connected to each other and foster themselves.

Science Education in 21st Century

These sections are given under experiments, technology based apps and distance teaching strategies.

Experiments: From Face to Face to Online

Science experiments are significant for learning science in science courses. Students learn science process skills via science experiments in laboraties. NARST (2020), these skills are titled under basic science process skills and integrated science skills. Basic science skills are observing, measuring, classifying, communicating, inferrring, predicting. Integrated science skills are controlling variables, defining operationally, formulating hypotheses, interpreting data, experimenting and formulating models. Experiments have been using for decades to teach scientific concepts to students in laboratories. Glass material, microskope, slide, coverslip, cylindir, plant models, DNA model and many concrete tools are used in laboratories during science experiments. To be able to learn science science experiments have much significant. But it is also known that some schools may not have well equipped laboratories since to set up a laboratory can be expensive. In this age we are in, different laboratories are needed. Within this perspective there can be seen some applications have been developed to be used in virtual laboratories during doing science experiments. In this labs virtual and augmented reality issues are mostly used. To illustrate this GO-LAB (2020), can be given as an example. Scientific concepts are taught with this project. Digital interactive experiments from scientific fields (chemistry, biology and physics, engineering, math, technology, astronomy) are implemented by students under guidance by their teachers. Students are able to create chemical reactions by using given matters, measure their weight via digital scales, can formulate the reaction and reveal results.

Students and teachers think themselves as they are in classes while conducting experiments. Both students and teachers must not be at the laboratories while conducting experiments in science course. Augmented and virtual reality based experiments support students within some aspects. Students have more opportunity to access scientific experiments and they must not use dangerous chemical contents.

Technology Based Apps

Recent years, tech based apps are more used in science courses. Specially, in vocational high schools and science centers these apps and applications can be seen in science based courses. 3D printers, CNC machines, robotic tools and apps, augmented reality tech, electronic programme and the things of internet are some of these. Pedaste, Kori, Maeots & Jong (2016), revealed that how a complex technology-enhanced learning environment should be designed. They found that in students' general inquiry knowledge, transformative inquiry skills, and domain- related knowledge in using a complex technology-enhanced learning environment SCY-Lab. Another technology based learning environment, Future Lab Classrrom (FCL), was created by European School Net. FCL is formed by six different learning spaces (EUN, 2012). Each space highlights specific areas of learning and teaching and helps to rethink different points: physical space, resources, changing roles of student and teacher, and how to support different learning styles with 21st centruy skills via new technology. Many kind of technological equipments are used. Some of them are flip camera, animation software, podcast software, online publication tools, OER content for IWB, Mind-mapping software etc.

In a near future we will see more technological tools in science education for students and teachers. Artificial intelligence and cyber security based apps will be more seen in science education. Students will use their own software while learning science subjects such as physics, chemistry and biology. For instance, some physics issues are really difficult to be learned. Density, force, gravity, mass, buoyant force (Archimeds' principle) can be given to illustate those issues. Students will see all possibilities while learning these issues without having difficulties or less diffilcuties.

Distance Teaching Strategies

Human have been facing many negative situations since its exist. Natural disasters, deseases, wars are some of them. Last of them is Covid-19 which we have been fighting for our health. Because of Covid-19 schools were closed for months and students and teachers could not go to classes. This is the first time that too many students and their teachers were not able to go to their schools for long time. Before Covid pandemic, TV, Youtube and some softwares were already used in science learning but not for millions of people. Herein distance teaching strategies are significant and its tools undertook responsebility. We actually learned that these tools would work or not. These educational applications, platforms and resources aim to help teachers and educators facilitate student learning and interaction during periods of school closure. Zoom, Adobe Connect, Paddle, Edpuzzle, Google meet, Padlet and Flipgrid can be given as examples in which we use in science teaching process. UNESCO (2020), classify these under "digital learning management systems, systems built for use on basic mobile phones, systems with strong offline fuctionality, massive open online course (MOOC) platforms, self directed learning content (Code Week, Code.org Discovery Education, LabExchang etc.) mobile reading applications (StoryWeaver), Collaboration platforms that support live-video communication (Skype, Zoom, Hangouts Meet) and tools for teachers to create of digital learning content (EdPuzzle and Trello)". It is seen that some companies, institutions created online courses for teachers to support their distance educatino during school clousure. For instance European School Net (2020) creates MOOCs within Project Based Learning, STEM Education. These freee online courses support teachers, who are around European countiries, to enhance their teaching practise. It is important and can be understood from a report by UN (2020), teachers across the globe were largely unprepared to support continuity of learning and adapt to new teaching methodologies in their teaching process. Besides this, it also emphasist that teachers were immediately tasked with implementing distance learning modalities, often without enough guidance, training, or resources. Within the light of all these given tools, it can be saşd that these tools may be efficiently used to get students towards science during school clousere. Scientific content should be prepared in accordance with science and its elements. Within both formal and non-formal science education these apps can be applied to the distance learning.

Conclusion

In 21st century we are in has taught us that we have to awere of technology and its use in science education. Since we have been facing the Covid-19 pandemic, more attention is needed to tackle inequalities in science education. Considerable attention should be more given to the use of technology to provided learning and teaching science continuity. Students should have free and open Access science educational resources for their learning science process. All students must Access to science education's instruments during learning science. In this age, it can not be claimed that science education basicly depends on technology but it is necessary that science education should be benefied from tehcnology and its resources. For having a global success in science education in 21st century, research and international engagement are necessary.

References

Akerson (2018). Defining the "S" in STEM: Nature of science as a component of STEM literacy. M. Shelly, S. A. Kıray (Eds), *Research highlights in STEM Education*. Ames: ISRES Publishing.

Aydoğdu, C. (2003). The effect of problem based learning strategy in electrolysis and battery subject teaching. *H. U. Journal of education, 42,* 48-59.

European School Net (2020). European School Net Academy-Online Courses. Retrieved from: http://www.eun.org/tr/professional-development/academy

Bybee, R. W. (2013). *The Case for STEM Education: Challenges and Opportunities.* Arlington, VA: NSTA Press.

European School Net (2012). Learning spaces. Future Classroom Lab learning zones. Retrieved from: https://fcl.eun.org/learning-zones

GO-LAB (2020). Sharing and Authoring Platform. Retrieved from: https://www.golabz.eu

Gonzales, H.B. & Kuenzi, J.K. (2012). Science, Technology, Engineering, and Mathematics (STEM) Education: A Primer. Crs report for Congress. Retrieved from: http://www.stemedcoalition.org/wp-content/uploads/2010/05/STEM-Education-Primer.pdf

Harris, K. R., Graham, S. E., Urdan, T. E., Bus, A. G., Major, S. E., & Swanson, H. (2012). *APA educational psychology handbook, Vol 3: Application to learning and teaching* (pp. 403-425). American Psychological Association.

Isabelle, A.D. & Valle, N. Z. (2016). *Inspiring STEM Minds.Biographies and Activities for Elementary Classrooms*. Rotterdam/Taipei/Boston: Sense Publishers.

Idin, Ş. (2018). An overview of STEM Education and industry 4.0. M. Shelly, S. A. Kıray (Eds), *Research highlights in STEM Education*.Ames: ISRES Publishing.

Justice, C., Rice, J. and Warry, W. (2009). Academic skill development – Inquiry seminars can make a difference: Evidence from a quasi-experimental study. *International Journal of Scholarship of Teaching and Learning, 3*(1): 1–23.

Kahn, P. and O'Rourke, K. (2004). Guide to curriculum design: Enquiry-based learninghttp://www.heacademy.ac.uk/resources/detail/resource_database/id359_guide_to_curriculum_design_ebl

Kokotsaki et al., 2016 D. Kokotsaki, V. Menzies, A. Wiggins. Project-based learning: A review of the literature. *Improving Schools, 19* (3) (2016), pp. 267-277.

Kyza, E. A., Herodotou, C., Nicolaidou, I., Redfors, A., Hansson, L., Schanze, S., ... & Michael, G. (2014). Adapting web-based inquiry learning environments from one country to another: The CoReflect experience. I*n Topics and Trends in Current Science Education* (pp. 567-582). Dordrecht: Springer.

Lin, T.Z., Lin, T.Z., Potvin, P. & Tsai, C. (2019). Research trends in science education from 2013 to 2017: A systematic content analysis of publications in selected journals. *International Journal of Science Education*, *41*(3), 367-387.

Loyens, S. M. M., Kirschner, P. A., & Paas, F. (2012). Problem-based learning. In K. R. Harris, S. Graham, T. Urdan, A. G. Bus, S. Major, & H. L. Swanson (Eds.), *APA handbooks in psychology. APA educational psychology handbook, Vol. 3. Application to learning and teaching* (p. 403–425). American Psychological Association. https://doi.org/10.1037/13275-016

NARST, (2020). The Science Process Skills. Retrieved from: https://narst.org/research-matters/science-process-skills.

National Research Council. (2010). *Exploring the intersection of science education and 21st century skills: A workshop summary*. National Academies Press: Washington DC.

OECD (2019). PISA 2018 Results Combined Executive Summaries Volume I, II & III. Retrieved from: https://www.oecd.org/pisa/Combined_Executive_Summaries_PISA_2018.pdf

Partnership for 21st Century Skills (P21). (2011). *P21 common core toolkit: A guide to aligning the common core state standards with the framework for 21st century skills*. The partnership for 21st Century Skills, Washington, D. C.: Partnership for 21st Century Skills.

Pedaste, M., Kori, K., Mäeots, M., & de Jong, T. (2016). Improvement of Inquiry in a Complex Technology-Enhanced Learning Environment. In N*ew Developments in Science and Technology Education* (pp. 55-62). Springer, Cham.. DOI 10.1007/978-3-319-22933-1_6

Saavedra, A. R., & Opfer, V. D. (2012). Teaching and learning 21st century skills: Lessons from the learning sciences. In A *Global Cities Education Network Report* (pp. 35). New York: Asia Society.

Smith-Spronken, R. & Walker R. (2010). Can inquiry-based learning strengthen the links between teaching and disciplinary research? J*ournal Studies in Higher Education, 35*(6), 723-740.

Thomas, (2000). J.W. Thomas. A review of research on project-based learning: Report prepared for the Autodesk Foundation (2000) Retrieved from:http://www.bie.org/object/document/a_review_of_research_on_project_based_learning,

TIMSS (2015). TIMSS 2015 International Reports. Student Achievement. Retrieved from: http://timss2015.org/timss-2015/science/student-achievement/

Tsybulsky, D. & Muchnik-Rozanıv, Y. (2019). The development of student-teachers' professional identity while team-teaching science classes using a project-based learning approach: A multi-level analysis. *Teacher and Teacher Education, 79,* 48-59.

Unatid Nations (2020). Policy Brief: Education during COVID-19 and beyond. Retrieved from: https://www.un.org/development/desa/dspd/wpcontent/uploads/sites/22/2020/0/sg_policy_brief_covid-19_and_education_august_2020.pdf

UNESCO (2020). Distance Learning solutions. Retrieved from: https://en.unesco.org/covid19/educationresponse/solutions

Weaver, F.S.,(Ed.). (1989). *Promoting inquiry in undergraduate learning New Directions for Teaching and Learning,* San Francisco: Jossey-Bass.

World Economic Forum (2020a). Davos 2020: Here's what you need to know about the future of work. Retrieved from: https://www.weforum.org/agenda/2020/01/davos-2020-future-work-jobs-skills-what-to-know/

World Economic Forum (2020b). The Future of Jobs Report. Retrieved from: http://www3.weforum.org/docs/WEF_Future_of_Jobs_2020.pdf

A Desirable but Difficult Goal: Equitable Assessment

Kevser Bozkurt
Gazi University
Kemal Izci
Necmettin Erbakan University

Introduction

Researchers in education have made grade progress supporting all students' learning by providing effective practices. Based on the efforts, teachers' practices of teaching have shifted from teacher-centered instructions to student-centered instructions. However, this shift in teachers' instructional practices is not adequately reflected in teachers' assessment practices. It is well-established that assessment and learning are interwined. Besides, how is assessment carried out and what is being assessed inform student learning. Therefore, assessment practices are essential to engage students in deep learning and closing the achievement gap between diverse students. Using assessment processes to support student learning rather than just providing grades is conceptualized as formative assessment or assessment for learning in literature.

Researchers have shown that formative assessment has a positive impact on students learning outcomes (Black & Wiliam, 2006; Vogelzanga & Admiraal, 2017). Formative assessments require teachers to elicit students' ideas, use these initial ideas to base instruction, and provide effective feedback and instruction to help students achieve the desired learning outcomes (Abell & Siegel, 2011). While the contributions of formative assessment on students learning are evident, it is difficult for teachers to change their traditional perceptions and practices of assessment to aid student learning (Izci, 2016). Researchers indicated that although teachers' perceptions of assessment have mostly changed based on the educational development within the last two decades, teachers' assessment practices resist to change because of various personal and contextual factors (Izci, 2018). Particularly, it is difficult for teachers to use assessment processes to engage all students and provide individualized assessment practices for diverse groups of learners within crowded classrooms.

Individual differences affect learning outcomes, learning speed, amount of learning, and transfer of the learned concepts into real life. Thus, these differences are effective in letting students show what they have learned. Considering individual differences during assessment practices is crucial if our aim is to support all students' learning through classroom assessment. Teachers need to use assessments to elicit, assess and support diverse students' learning (Lyon, 2017; Siegel, 2014). Use of assessment practices in providing equal opportunities for all students to engage in learning and show their learning is important and known as equitable assessment. Equitable assessment contains using student sensitive assessment tasks and processes to allow all students equally illustrate their thinking and accordingly providing personalized actions including tailored feedback to aid all students' learning (Siegel, 2014; Suskie, 2000). If our aim is to let all students learn key concepts and skills to become informed citizens in real life, equitable assessment is a pivotal instructional practice to respond to the needs of the diverse population of learners in our classrooms. This is also more important nowadays since the diversity of learners in classrooms has increased in all nations because of the migrations within and across national borders.

Increased diversity of students within schools has motivated countries to find ways and prepare teachers to effectively use diversity as a means to respond to the needs of diverse students. Equitable assessment is one of the ways we can utilize diversity as an opportunity to support diverse students' learning needs. Some countries, such as Turkey, started to require teacher preparation in using equitable assessment practices to promote students learning. For example, the Ministry of National Education (MoNE) of Turkey determined equitable assessment practices as a prerequisite for teachers and published "The General Qualifications of Teaching Profession" standards (MoNE, 2017). These standards, for instruction, require teachers to, first, "develop a flexible instructional plan to respond to individual differences and sociocultural characteristics of students" and, second, to "design a learning environment by considering individual differences and needs of learners." (MoNE, 2017, p. 14) Specific to equitable assessment practices of teachers, these standards require teachers to "prepare and use diverse assessment tools and methods suitable to students characteristics" and "Carrying out an objective and fair assessment." (MoNE, 2017, p. 22)

Based on the critical role of equitable assessment explained above, in order to inform researchers and practitioners, the chapter aims to provide conceptions of equitable assessment, explain the individual differences need to be considered during equitable assessment and suggest research-informed principles for successful equitable assessment practices.

Conceptions of Equitable Assessment

Based on the developmental movements in human rights and civilization areas, concepts like diversity, equity and social justice have increasingly been discussed among researchers in the educational community. However, many researchers use these terms inattentively rather than explaining what these terms are and how they address these terms in their studies (Rodriguez & Morrison, 2019). It is important for stakeholders of educational communities to more clearly define their philosophical and theoretical views of diversity, equity and social justice in order to provide a clear picture of their works. Since there are contradictory views regarding diversity, equity and social justice in the literature, it is also essential for assessment researchers to explicitly define these constructs and explain how they support or address these concepts within assessment practices and processes.

In particular, for classroom assessments, the results of a systemic literature review conducted by Rodriguez and Morrison (2019) showed that most of the reviewed studies used different terminologies while addressing fairness in assessment. In addition, the analysis of the same studies by Rasooli, Zandi and DeLuca (2019) indicated that only 8 of 50 studies provided a clear definition of fairness for classroom assessment. Furthermore, it was shown that researchers use different terminologies such as equity, justice, equality, ethics, equitable, and nondiscriminatory to indicate fairness of assessment in their studies. The use of different terminologies interchangeably makes it difficult for readers to understand what constitutes a fair assessment and how to interpret the results of studies conducted about fairness of assessment. As Rasooli et al. (2019) explained, it is important for researchers to provide more detailed definitions of these terms used for fairness because fairness of assessment is a multifaceted and fuzzy concept. For example, as Rasooli et al. (2019) indicated several researchers use equitable assessment as to provide equal opportunities for learners to engage in learning and assessment while other researchers use it as a way of providing equal assessment opportunities for all learners to illustrate their learning regardless of individual differences. Thus, it is essential for researchers to clearly provide their approaches to equitable assessment and consistently use the same approaches to interpret and discuss the results of their study.

On the other hand, because of the nature of fairness, it is difficult to clearly define and come to a consensus on a definition for fairness of assessment (Rodriguez & Morrison, 2019). One of the dilemmas among researchers for fair assessment is the binomial of equality-equity. As Nisbet and Shaw (2019) stated, researchers mainly consider the conception of equity or equality to base their understanding of fairness. The researchers using the notion of equality to address fairness of assessment highlight the equality of conditions, such as time, resources and materials when applying an assessment to students (Tierney, 2014). Equality perspective mostly focuses on objectivity and requires teachers to be objective when applying, scoring and interpreting an assessment activity.

Contrary to the equality notion, some authors (e.g., Siegel, 2014; Suskie, 2002) argue that the mere ensurance of objectivity cannot support fairness of assessment since all students do not have the same opportunities to access education and assessment. In order to support fairness of assessment and principles of equity, the uses of different forms, accommodations and adaptations of assessments need to be employed to address students' needs and characteristics during assessment practices. Similarly, McArthur (2018) states that equity is an important requirement to develop a fair assessment and it is necessary for teachers to use multiple forms of assessment to address diversity of students during assessment practices.

Reflections on equality-equity notions of assessment in the related literature show that researchers point out different reasons and prioritize different constructs to address fairness of assessment. Particularly, researchers considering the role of assessment in comparing students achievement more likely to support the equality notion since achieving equality of assessment makes the comparison more meaningful and reliable (Zieky, 2016). On the other hand, achieving equity of assessment is vital to limiting bias and engage all students' in learning and assessment processes; however, it makes difficult to compare students and placement of students. Thus, it is important to identify which conceptions of assessment fairness are valuable for us and, accordingly, design, conduct, and interpret our endeavors for assessment fairness. Furthermore, conceptions of fairness also depend on the function of assessment such as high-stake assessment or classroom assessment because the comparison of students and grades are important in high-stake assessments than they are in classroom assessment. It is also evident that students encounter classroom based assessments more frequently than high-stake assessment on a daily basis. Therefore, it is meaningful for us to consider classroom based assessment to approach fairness of assessment by highlighting the equity notion, conceptualized as equitable assessment, to support student engagement and learning.

Mpofu and Ortiz (2009) indicated four essential conditions in lassifying equitable assessment. These perspectives include;

1) from the application of measures with cross-population transportability;

2) use of items that are equivalent in measuring the construct of interest;

3) knowledge of the manner in which certain variables (culture and language) affect test performance; and

4) application of a systematic approach designed to evaluate the influence of cultural and linguistic difference on the validity of obtained results (Mpofu & Ortiz, 2009, p. 42).

As Mpofu and Ortiz (2009) noted that the first two conditions are related to the technical requirement of assessment and mostly necessary for high-stake assessments. The last two conditions are related to the context in which the assessment is used, the personal characteristic of assessment users, and the outcomes and interpretations of the assessment results. Thus, the last two conditions are more important to classroom-based assessment applications and needed to be considered by teachers and researchers in providing effective and equitable assessment practices to their students. In this chapter, we interpret that classroom assessment is a process collects and uses student-related data to inform instruction and support learning. As teachers have more opportunities to collect first hand data via different form of assessments about diverse learners to make instructional decisions in their classrooms, classroom based assessments are more influential in informing and aiding students' learning. Thus, teachers' understanding and practices of equitable assessment are vital in order to ensure effective learning for all students.

Based on the Mpofu and Ortiz's (2009) classifications of equitable assessment, it is important for teachers to know which factors affect students engagement and practices of assessment and how these factors can be addressed to reduce bias and provide equitable opportunities for students to engage in the assessment process to show their learning. Thus, we next aim to provide the factors that influence learning and assessment of learning.

The Individual Differences that Need to be Considered During Equitable Assessment

Equitable assessment aims to support all students' learning through providing differentiated assessment opportunities for diverse groups of learners to let them engage and illustrate their learning without any direct or implicit bias for any group of students. Thus, it is important for administrators of classroom assessment to be well-informed about the differences diverse groups of learners bring to their classrooms, how these differences influence students' learning process and how to provide tailored assessment practices to meet the needs of diverse students. In order to provide some background knowledge of individual differences for teachers, this section addresses the differences students bring to classrooms and explain how these differences influence learning and engagement to assessment practices.

Intelligence

A number of terms, such as bright, fast-paced, used by teachers for some of their students are generally associated with intelligence (Gardner, 2017). Intelligence is the most important factor affecting student performance, and it affects school learning by 25 percent alone (Borich, 2017, p. 43). There are many definitions of intelligence. By explaining intelligence based on evolution, Piaget stressed adaptation and reaching to a state of balance in the biological sense (Piaget, 2016 p.14). On the other hand, Gardner explained intelligence with abilities shown in different fields. According to Gardner, completely different achievements cannot be explained by a single type of intelligence, so he expressed intelligence as different cognitive abilities managed by different parts of the brain (Gardner, 2017, p.125). Intelligence, according to Gardner, is not simply a skill that can be measured with paper and pencil. Thus, as intelligence influences learning, it also influences how students illustrate their learning. Teachers need to use diverse assessments that address the differences in students' cognitive abilities and afford these students to engage in different assessment practices to learn and show their learning based on their cognitive abilities.

Culture

Students from different cultures can react differently to the teacher's behavior in the classroom. Various stimuli, such as proximity control, eye contact, and classroom order are perceived differently by different cultures. Consciously or not, because of the cultural differences, students feel close to some of their classmates and want to be in a group with them while they ran away for some of their classmates and do not feel comfortable with them (Borich, 2017 p.48). Culture affects people's way of thinking and influences information processing, interpretation and problem solving methods. Therefore, culture affects both one's learning process and the classroom assessment to be employed (Lee & Penfield, 2010). Researchers indicate that teachers need to consider cultural differences of learners when designing and applying assessment tasks and providing feedback to their students (Solano-Flores & Nelson-Barber, 2001). Students' cultures both influence how they interpret assessment items and the ways they response to the items because culture shape students' mind. Culture forms students' living environment and this environment influences students' developments and characteristics. Based on the sociocultural perspective, students socialize within the surrounded culture and the culture influence how they think, interpret and act on learning tasks. According to Flores and Nelson-Barber (2001), there are five areas that assessment developers and users, including teachers, should consider when developing and administrating assessment to address cultural diversity of students within classroom assessment. They are (a) student epistemology, (b) student language proficiency, (c) cultural world views, (d) cultural communication and socialization styles, and (e) student life context and values. As knowledge is a socially constructed concept, the areas Flores and Nelson-Barber (2001) indicate influence students' learning and also illustration of learning via classroom assessments.

Socioeconomic Status

When socioeconomic status is considered, not only the family's financial purchasing abilities but also all family-based factors that may affect the education life of the school-age child should be taken into account. Among these factors, the structure of the family, the place of the child in the family, access to technology and communication tools, health and nutrition conditions, and the relocation cyclin family can be counted. Considering that the child starts learning before school age, language and speaking skills are affected by the experiences that the family provides to the individual. The reading and speaking skills of an individual who can access social networks, books, magazines, and cultural activities develops more easily and faster than an individual with limited access to them. What is striking here is that although the racial origin of the student does not have a strong effect on learning, the socioeconomic status does have a significant effect (Borich, 2017). Here, the structure of the family is also worth noting. Buldu and Olga (2018) examined some variables with the development of science literacy skills of 15-year-old students from Turkey based on the PISA results. The results of their study showed that there is a significant relationship between the education level of the family and student achievement. In this study, students' pre-school education was also examined. It was shown that starting pre-school education at the age of 2, 3, and 4 had a high positive effect on students' science literacy skills (Bulur & Olgan, 2018). Thus, we can say that the family's socioeconomic status a student lives in influences the student's achievement and accordingly influences student's interpretations and responses to assessment practices.

Language

Students ability to transfer their life outside of school which contributes to their academic development depends on the use of language. When a language is used in different ways at school and at home, a disconnection begins between home and school in student life (Borich, 2017). For this reason, the rate of similarity between the language used in the classroom and the language used at home also affects academic achievement (Oral & Mcgivney, 2014). Carson (2019) conducted a study using data from students whose native language is English and those who are not. Based on the results of the study, the difference in success between the two groups is undeniable and the achievement of English Language Learners (ELL) are lover than those of native speakers. Students who have to learn a language simultaneously with academic knowledge are struggling with difficulties that can be reflected in their education life due to traumas such as poverty, lack of parental support, lack of opportunities and migration. Similarly, Heaton and Afitska (2019), conducted a study with elementary level students whose native language is not English, and found that students had trouble using scientific terms and interpreting arguments correctly, and using visual elements. They especially suggested that scientific terms should be taught starting from the first grade. The language use in assessment tasks is also important and influences students' interpretations and ultimately responses to assessments. Therefore, it is suggested that the language used in the assessments needs to reflect the language used in the classroom. Also, teachers need to use clear, understandable and simple language in assessment tasks to support ELLs engagement in assessment processes to illustrate their learning (Lyon, 2013; Siegel, 2007).

Learning Style

Students have different learning styles, compatible with their personalities, which they use to learn and show their learning. These learning styles vary among students in the same class (Özgen, Ay, Kılıç, Özsoy, & Alpay, 2017). Students may be susceptible to different learning styles due to their demographic background or even their gender alone. Female students prefer to use concrete life examples and male students prefer abstract conceptualization generally. Learning styles affect academic success in the classroom depending on the instructional strategies, contexts and activities that teachers make available for students (Kazu & Koç-Akran, 2018). It is important for teachers to consider variations of learning styles of their students when designing and practicing assessment tasks to evaluate and support their students' learning. The use of more diverse assessment methods can help teachers to address the needs of students with different learning styles. Teachers also need to handle different ways to provide individualized feedback to their students based on their learning styles.

Readiness and Prior Knowledge

Individuals try to make sense of the world and to structure new information thanks to their prior knowledge. The story of a small fish and a frog is told in the children story Fish Is Fish, published by Lionni in 1970. According to the story, the frog experiences the outside world for a while and when he returns a few days later, provides descriptions of the people, birds and other beings he saw to other fish. When the frog explains the traits of the different living beings, the fish always compares what the frog tells to the walking, winged or speckled fish using his prior knowledge and experience (Lionni , 1970). This story is very revealing in showing how important the prior knowledge and experiences of the fish play in understanding what the frog is telling, with its role corresponding to the teacher. According to the constructivist learning theory, students build new knowledge on the knowledge they already possess. Pre-existing knowledge may have been acquired at school and in everyday life via socialization. As long as the preliminary knowledge is compatible with new knowledge, it makes learning easier. In cases where it is incompatible, learning becomes difficult (Köseoğlu & Tümay, 2015). Since no student live the same life with their peers, a student cannot be equal with another in the classroom environment. Therefore, when using assessment for diagnostic purposes, teachers need to consider students' prior experiences to structure assessment items to elicit students' learning. Otherwise, students cannot provide usable knowledge that teachers use to base their instructional planning and practices.

Gender

Social roles prevent girls and boys from being equal in the classroom (Banks, 2010). Individuals form an understanding, a way of thinking and a lifestyle pattern that is centered on their gender from birth (Vatandaş, 2011). The study of Aslan (2017), onducted based on national exams results of Turkey, showed that females are more successful than males.

According to the author, this is due to the anxiety that unsuccessful female students will be forced to end their school life. There are also studies reporting that gender has no effect in the teaching environment (Horzum, Alper, 2006; Maden, Durukan, Akbaş, 2013). However, although it does not affect success, it was stated in these studies that gender affects teaching preferences and perceptions. Thus, gender is thought as a factor that influences people preference of assessment tasks. For example, as females like to talk more and feel comfortable when talking about concepts, they are more comfortable with oral exams than males. Therefore, teachers need to provide different assessment formats to offer students ways to engage and show their learning through assessment.

Special Needs

Although intellectual disability is generally the first thing comes to mind, there are also students with visual, hearing, orthopedic and types of disabilities in schools. These students are referred to as students with special needs. Students may not be able to participate in visual, auditory or physical learning and assessment activities depending on the type of special needs. They can learn more slowly. They may be restricted in some behaviors such as writing, reading, navigating the classroom, and speaking. These situations affect their participation in the learning environment, their learning rate, and their demonstration of what they have learned. Thus, countries have laws and regulations for the education and assessment of students with special needs. For example, these students are prepared for the type of instructional plans organized according to their needs and their assessments are also applied according to this plan. However, the system is not without problems. Accordingly, students with special needs cannot communicate effectively with their peers with an average development level, and schools are insufficient to encourage students in this direction. It is also stated that inclusive education, which aims to educate students with special needs with their peers without special needs, is not effectively implemented in schools (Demir & Kale, 2019).

Assessment activities should also be included in the regulation of educational environments for students with special needs. Evaluating all students with the same assessment tools in national exams creates some drawbacks. Although supporting visually and physically disabled students by providing transcripts and/or reader support in national exams eliminates some disadvantages, it does not solve the problems arising from the content of the question items. Particularly, using visual images and abstract concepts can cause bias in the assessment of students for some disability groups (Yılmaz, 2019). Student diversities have been the source of the development of different teaching strategies. Differentiated education that focuses on advancing the student from where they are located; inclusive education that envisages the education of students with special needs in the same class with their peers according to programs specially prepared for them; multicultural education that advocates that students from different cultures find traces of their own culture in their school are examples of teaching approaches based on individual differences. In the same line, equitable assessment, sensitive assessment and fair assessment terms are used by researchers to address students of special needs in order to provide them effective assessment practices.

Research-Informed Principles for Successful Equitable Assessment Practices

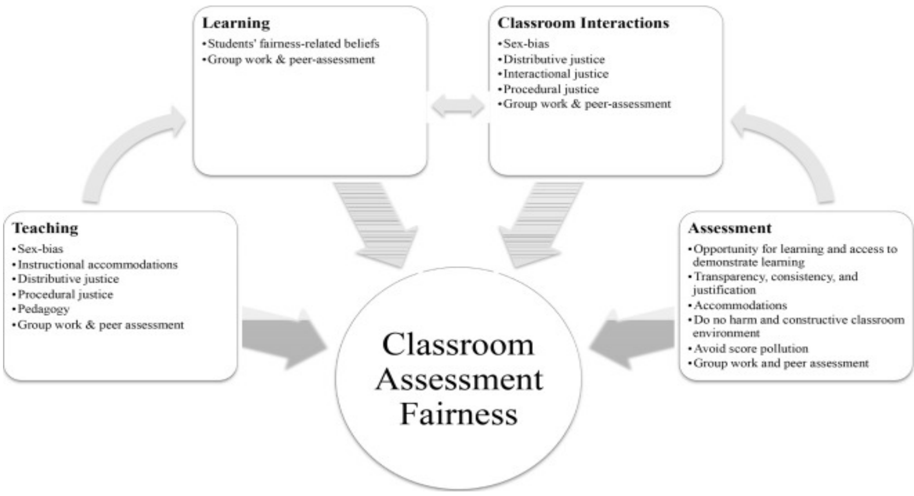
Especially in multilingual countries, students whose mother language is different from the language of instruction consistently get lower grades than others (Hockings, 2008). Students' achievement is affected by the difference between the language spoken at home and the language spoken in the classroom (Oral & McGivney, 2014; Carson, 2019). Apart from language, there are also differences among students in many areas as mentioned above. These differences do not make it possible to achieve an active teaching or an effective assessment with a single method. At this point, the egalitarian assessment approach, which advocates for the ability of students to demonstrate what they have learned with the most appropriate method based on individual differences, emerged. Even though equitable assessment emerged due to difficulties arising from native language differences among students, this approach was adopted to encompasses all individual differences that affect learning.

The equitable assessment approach is based on the principles of taking into account individual differences, assuring transparency, providing opportunities for every student to show what they have learned during assessment processes (Tierney, 2016). Standardized tests, particularly tests prepared with a single method, create advantages for some students and disadvantages for others, which prevents the provision of justice. Therefore, diversified assessment tools should be used to let all students show their learning (Barrance, 2019).

As the source of differences between students changed, researchers developed different definitions for equitable assessment. For example, Montenegro, Natasha and Jankowski (2020) reviewed the literature for equitable assessment and provided three different terms, including culturally sensitive assessment, socially fair assessment and critical assessment by focusing on different dimensions of equitable assessment. Culturally sensitive assessment refers to the inclusion of students in the assessment process by recognizing their cultural background. Socially fair assessment refers to assessment without biases that support students' learning, and critical assessment refers to an assessment approach that combines both cults. On the other hand, some researchers define equitable assessment based on two different points as justice and access. In the focus of justice, some assessments are compatible with the individual differences that students bring to the classroom. For example, a teacher who takes into account the difference in the native language, which is an individual difference, carries out the learning process with an understandable language, uses a plain language suitable with the language of instruction in the assessment tools, and designs and uses different and enriched assessment tools. In the focus of access, it is important that all students have equal learning opportunities. For this purpose, targeted concepts can be explained and discussed in different ways, thus creating opportunities for learning and expression for each student (Lyon, 2013).

Rasooli, Zandi, and DeLuca (2018) found 6 different themes for equitable assessment based on the findings of the publications they examined meta-ethnographically in the focus of equitable/fair assessment. According to the authors, these themes or principles are important to provide equitable/fair assessment practices to learners. These themes are; a) allowing everyone to learn and show what they have learned, b) transparency, consistency and accountability in assessment, c) adapting educational activities or assessment activities that do not deviate from the target gains, d) not harming the student and their family in assessment and being constructive in the classroom, e) avoiding extracurricular evaluations and grading; and f) group work and peer reviews. In the aforementioned study, the authors argued that assessment should also be considered together with learning, teaching, and classroom interaction. More attention should be paid to the literacy of teachers. According to the relevant study findings, the authors proposed a model consisting of four elements for equitable/fair assessment. According to this model, in order to achieve equitable/fair assessment, learning, teaching, classroom interaction and assessment elements should be taken as a basis. When Figure 1 is examined, it is seen that the themes given above are interrelated. An understanding of justice that dominates the whole process is reflected for a fair payment, thus the learning-teaching process is intertwined with assessment.

Figure 1. Classroom assessment fairness in the intersection of four elements of classroom practice adapted from Rasooli, Zandi, and DeLuca (2018, p. 177).



Educators should take into account the individual differences of their students in assessment administration since the basis of the equitable assessment is based on this.

In this context, especially teachers, who are the guide of education, have more work. Teachers who believe that the differences between students can affect the learning process tailor their instruction according to their students' needs, while teachers who think that the differences between students will not affect success may plan their lessons without considering these differences (Lee, Luykx, Buxton, & Shaver, 2007). Thus, it is important for a successful equitable assessment practices to motivate teachers to change their conceptions of assessment to meet the needs of diverse students. However, this is not enough since teachers have difficulty equitably assessing their students' learning (Lyon, 2013). Teachers need guidelines, materials and examples of equitable assessment practices in order to change their traditional practices of assessment. In this context, Siegel, Wissehr ve Halverson (2008) provide a useful framework, McCes-Sounds Like Success, that includes some guiding principles to develop culturally and linguistically sensitive assessment tasks to assess student learning equitably. According to the authors, classroom assessments should be challenging but also inclusive and helpful for diverse learners. The authors provided five principles for teachers to develop and use such assessments to aid all their students' learning. They are; a) match the learning goals and the language of instruction, b) be comprehensible for English learners, both linguistically and culturally, c) challenge students to think about difficult ideas, d) elicit student understanding, e) scaffold the use of language and support student learning (Siegel et al., 2008, p.44). The authors also provided some recommendations such as using simplified language, providing extra time, reading questions aloud, using scaffolding, and allowing use of the dictionary to reduce language challenge for English learners without lowering content.

Similar suggestions are also provided by Lyon (2013) and Yang (2019) to support English learners' engagement in and illustration of learning. Yang (2019) indicates that language minorities have difficulties illustrating their understanding of content knowledge because of language barrier. Thus, assessment accommodations are emerged as a way for linguistically and culturally diverse learners to be assessed fairly. Assessment accommodation is known as the use of different alterations of an assessment task or assessment process without lowering content. Researchers indicated that assessment accommodations help language minorities more accurately reflect their content knowledge and increase their scores (Lopez, Guzman-Orth, & Turkan, 2019; Pennock-Roman & Rivera, 2011). Yang (2019) provided four principles for deciding what types of accommodations to use for language minorities. First, the accommodations should meet the needs of students. Thus, when deciding to choose an assessment accommodation, learners' language proficiency, cultures, native language, grade and age levels, and language of content areas need to be taken into account to provide the most appropriate accommodations. Second, collaborations of experts such as language teachers, classroom teachers and/or special education teachers are also important to make decision about the proper assessment accommodations for language minorities. Third, use of some online programs can help teachers to decide how to provide changes to their assessments for their language minority students. STELLA (the selection taxonomy for English language learner accommodations) is an example of such online programs that help teachers find most suitable types of assessment accommodations for their students (Koran & Kopriva, 2017). Lastly, teachers also use some types of rubrics that researchers developed to guide their selection of accommodations for their students. These types of rubrics usually provide detailed criteria that guide teachers to analyze the planned accommodations to decide if the accommodations meet the needs of students. The Smarter-Balanced Assessment Consortium (SBAC) developed by Abedi and Ewers (2013) can be an example of such guidelines.

American Association for Higher Education also provides some guiding principles for educators to follow in order to fairly assess their student learning regardless of their differences. According to Suski (2000), director of the evaluation department of AAHE (American Association for Higher Education) in the USA, teachers need to follow seven steps in order to be fair in classroom assessments. The first step requires teachers to clearly state learning outcomes to share with students to inform them what they expected to learn. Second, match your assessments to what you teach because what knowledge and skills are focused on instruction also need to be assessed by assessment tasks. Third, use diverse assessment methods and assessment items to fit the needs of different learners. Fourth, helping students to learn how to complete the assessment task since some students may new to the types of provided tasks or they do not know how good responses to the assessment tasks look like. Fifth, engage and encourage your students since the relationship between students and teachers affects student performance. Therefore, teachers need to create an inclusive learning environment to make students feel comfortable, engage them, and show their learning. Sixth, interpret assessment results appropriately since assessing students is done for different purposes. For example, when choosing students for a chess tournament, it would be appropriate to select the best ones by ranking, or when finishing a training module, it should be evaluated whether they have gained the necessary competencies for the next module. If teaching is aimed at developing the student, it is necessary to see the student's progress according to the starting point. Finally, evaluate the validity of your assessments since assessment tools that are not clear enough or ambiguos to students may be assessing another trait that was not intended.

Conclusion

It is unfair for teachers to treat all students equally because not all students are equal. Students' learning styles, socio-economic standards, predominant intelligence areas, prior knowledge, and cultural structures that directly affect their perception of events and concepts are different. Since the knowledge is structured in individuals' mind individual understanding can be expected to be different even after exposure to the same topic. Instead of trying to consider the students equal, the main goal should be to make students go further than where they are. Considering individual differences in terms of disability will also misguide teachers to disregard other individual differences of students. For these reasons, disability should be considered only one of the dimensions of individual difference among others in order to fairly assess and aid all students' learning.

Assessment in teaching should also be student-centered, aligning with the student-centered teaching approach. Just as shoes bought from a store will not fit every foot, not every assessment tool will fit every student. For this reason, assessment methods should be diversified based on student needs. Teachers need to avoid using only paper and pencil tests, and assess the students' performances and progress from the beginner levels (Yabaş & Altun, 2009; Suskie, 2000). Time can be saved by determining the commanilities across students and developing assessment tools according to these common points. Furthermore, assessments that requires students to work in groups will be fairer than assessments applied equally to all students (Lee & Penfield, 2010, Siegel, Roberts, Freyermuth, Witzig & Izci, 2015).

Changing teachers' traditional practices of classroom assessment is not an easy task. Firstly, we need to support teachers to comprehend aims, contents and ways in which equitably assessing student learning. Second, it is important for teachers to believe that equitable assessment is a useful and doable endeavor. Third, researchers need to support teachers by providing guiding rules, materials and examples of equitable assessments to facilitate teachers' practices. Lastly, teachers should constantly strive to find ways to develop sensitive assessments to meet diverse students' needs.

References

Abedi, J., & Ewers, N. (2013). Accommodations for English language learners and students with disabilities: A research-based decision algorithm. Retrieved from https://portal.smarterbalanced.org/library/en/accommodations-for-english-language-learners-and-students-with-disabilities-a-research-based-decision-algorithm.pdf

Abedi, J., Hofstetter, C. H., & Lord, C. (2004). Assessment accommodations for English language learners: Implications for policy-based empirical research. *Review of Educational Research, 74,* 1–28. http://dx.doi.org/10.3102/00346543074001001.

Abell, S. K., & Siegel, M. A. (2011). Assessment literacy: What science teachers need to know and be able to do? In D. Corrigan, J. Dillon, & R. Gunstone (Eds.), *The professional knowledge base of science teaching* (pp. 205–221). The Netherlands: Springer.

Afitska, O., & Heaton, T. J. (2019). Mitigating the effect of language in the assessment of science: A study of English-language learners in primary classrooms in the United Kingdom. *Science Education, 103*(6), 1396-1422.

Banks, J. A., & Banks, C. A. M. (Eds.). (2010). *Multicultural education: Issues and perspectives*. John Wiley & Sons.

Barrance, R. (2019) The fairness of internal assessment in the GCSE: the value of students' accounts, *Assessment in Education: Principles, Policy & Practice, 26(5)* 563-583, DOI: 10.1080/0969594X.2019.1619514

Black, P., & Wiliam, D. (1998). Assessment and classroom learning. *Assessment in Education, 5*(1), 7-74

Borich, G. D. (2017).(8. Baskıdan çeviri) *Etkili öğretim yöntemleri Araştırma temelli uygulama. Effective teaching methods research based practice* (Çev. Ed. M. B. Acat). Ankara: Nobel Yayınları.

Buldu, E., & Olgan, R. (2018). Fen okur-yazarlık beceri puanları arasındaki farklılaşmanın bazı göstergeler açısından incelenmesi: PISA-Türkiye bulguları. *Journal of Human Sciences, 15*(3), 1453-1465. doi:10.14687/jhs.v15i3.5279

Carson, K. (2019). *Scaffolding Kindergarten Writing For English Language Learners. A capstone submitted in partial fulfillment of the requirements for the degree of Master of Arts in English as a Second Language* (Master Thesis). Hamline University, Saint Paul, Minnesota.

Demir, S. ve Kale, M. (2019) İlkokullarda özel eğitim sınıflarında karşılaşılan sorunların incelenmesi. *Kırşehir Eğitim Fakültesi Dergisi, 20*(1), 354-373.

Gardner, H. (2017). *Zihnin çerçeveleri: Çoklu zekâ kuramı* (3. Baskı) *(Çev. Kılıç, E.). İstanbul: Alfa Yayınları.*

Hockings, Bhatti, P., Bibi, S., Murphy, S., Sandhu, L., Sahota, S., …..& Thomas, E. (2008). *Equitable Assessment for a Diverse Student Population Pilot Study Report.*

Horzum - Alper, M . (2006). Fen bilgisi dersinde olaya dayalı öğrenme yöntemi, bilişsel stilin ve cinsiyetin öğrenci başarısına etkisi. *Ankara Üniversitesi Eğitim Bilimleri Fakültesi Dergisi, 39* (2), 151-175.

İdin, Ş. & Aydoğdu, C. (2017). Fen bilimleri öğretmenlerinin sosyal adalet ve eşitlik perspektifinde fen bilimleri eğitimine ilişkin görüşleri. *Abant İzzet Baysal Üniversitesi Eğitim Fakültesi Dergisi, 17* (3), 1328-1349.

İzci, K. (2018). Turkish science teacher candidates understandings of equitable assessment and their plans about it. *Journal of Education in Science, Environment and Health, 4*(2), 193-205. DOI:10.21891/jeseh.436744.

Izci, K. (2016). Internal and external factors affecting teachers' adoption of formative assessment to support learning. *International Journal of Social, Behavioral, Educational, Economic, Business and Industrial Engineering, 10*(8), 2774-2781.

Kazu, İ. Y., & Koç-Akran, S. (2018). 5. ve 6. Sınıf Öğrencilerinin Öğrenme Stilleri ile Akademik Başarıları Arasındaki İlişki (Malatya ve Elazığ ili örneği). *Current Research in Education, 4*(2), 62-85.

Koran, J., & Kopriva, R. J. (2017). Framing appropriate accommodations in terms of individual need: Examining the fit of four approaches to selecting test accommodations of English language learners. *Applied Measurement in Education, 30*(2), 71–81. doi:10.1080/08957347.2016.1243539

Köseoğlu, F., & Tümay, H. (2015). *Fen Eğitiminde Yapılandırmacılık ve Yeni Öğretim Yöntemleri.* Ankara: Palme Yayıncılık.

Lee, O., Luykx, A., Buxton, C., & Shaver, A. (2007). The challenge of altering elementary school teachers' beliefs and practices regarding linguistic and cultural diversity in science instruction. *Journal of Research in Science Teaching, 44*(9), 1269–1291.

Lionni, L. (1970). *Fish is Fish*. New York: Alfred A

Lopez, A. A., Guzman-Orth, D., & Turkan, S. (2019). Exploring the use of translanguaging to measure the mathematics knowledge of emergent bilingual students. *Translation and Translanguaging in Multilingual Contexts, 5*(2), 143–164. doi:10.1075/ttmc

Lyon, E. G. (2013b). What about language while equitably assessing science? Case studies of preservice teachers' evolving expertise. *Teaching and Teacher Education, 32*, 1–11.

Lyon, E. G. (2017). Exploring secondary science teachers' enactment of assessment practices to reflect responsive science teaching for English learners. *Journal of Science Teacher Education, 28*(8), 674-698. DOI: 10.1080/1046560X.2017.1401415

Maden, S , Durukan, E , Akbaş, E . (2013). İlköğretim öğretmenlerinin öğrenci merkezli öğretime yönelik algıları/primary school teachers' perceptions of student centered teaching. *Mustafa Kemal Üniversitesi Sosyal Bilimler Enstitüsü Dergisi, 8* (16), 255-269.

Ministry of National Education (2017). *General Competencies for Teaching Profession General Directorate of Teacher Preparation and Development*, Ankara. Retrieved 12.16.2020 from http://oygm.meb.gov.tr/meb_iys_dosyalar/2018_06/29111119_TeachersGeneralCompetencies.pdf

Mpofu, E., Ortiz, J. (2009). Equitable assessment practices in diverse contexts. In Grigorenko, E. (Ed.), *Multicultural psychoeducational assessment* (pp. 41–76). New York, NY: Springer Publishing Company.

Montenegro, E., & Jankowski, N. A. (2020). *A new decade for assessment: Embedding equity into assessment praxis.* Occasional Paper No. 42, University of Illinois and Indiana University, NILOA, Urbana, IL.

Murillo, F. J., & Hidalgo, N. (2017). Students' conceptions about a fair assessment of their learning. *Studies in Educational Evaluation, 53*,10–16. http://dx.doi.org/10.1016/j.stueduc.2017.01.001

Murillo, F. J., & Hidalgo, N. (2020). Fair student assessment: A phenomenographic study on teachers' conceptions. *Studies in Educational Evaluation, 65*, 100860. https://doi.org/10.1016/j.stueduc.2020.100860

Nisbet, I., & Shaw, S. D. (2019). Fair assessment viewed through the lenses of measurement theory. *Assessment in Education: Principles, Policy & Practice, 26*(5), 612-629.

Oral, I. & Mcgivney, E. J. (2014). *Türkiye eğitim sisteminde eşitlik ve akademik başarı araştırma raporu ve analizi.* İstanbul: Sabancı Üniversitesi Yayınları.

Özgen, K., Ay, M., Kılıç, Z., Özsoy, G., & Alpay, F. N. (2017). Ortaokul Öğrencilerinin Öğrenme Stilleri ve Matematiksel Problem Çözmeye Yönelik Tutumlarının İncelenmesi. *Mehmet Akif Ersoy Üniversitesi Eğitim Fakültesi Dergisi, 1*(41), 215-244.)

Penfield, R. D., & Lee, O. (2010). Test-based accountability: Potential benefits and pitfalls of science assessment with student diversity. Journal of Research in Science Teaching: The Official *Journal of the National Association for Research in Science Teaching, 47*(1), 6-24.

Pennock-Roman, M., & Rivera, C. (2011). Mean effects of test accommodations for ELLs and non-ELLs: A meta-analysis of experimental studies. Ed*ucational Measurement: Issues and Practice, 30*(3), 10–28. doi:10.1111/emip.2011.30.issue-3

Piaget, J. (2016). *Zeka psikolojisi*. (Çev: Yılmaz, İ. H.). İstanbul: Pinhan Yayıncılık.

Rasooli A. Zandi H. ve DeLuca C. (2018) Re-conceptualizing classroom assessment fairness: A systematic metaethnography of assessment literature and beyond. *Studies in Educational Evaluation 56* (2018) 164–181. https://doi.org/10.1016/j.stueduc.2017.12.008

Rasooli, A., DeLuca, C., Rasegh, A., & Fathi, S. (2019). Students' critical incidents of fairness in classroom assessment: An empirical study. *Social Psychology of Education, 22*(3), 701-722.

Rasooli, A. Zandi, H. & DeLuca, C. (2019) Conceptualising fairness in classroom assessment: Exploring the value of organisational justice theory, *Assessment in Education: Principles, Policy & Practice, 26*(5), 584-611, DOI: 10.1080/0969594X.2019.1593105.

Rasooli, A., Zandi, H., & DeLuca, C. (2018). Re-conceptualizing classroom assessment fairness: A systematic meta-ethnography of assessment literature and beyond. *Studies in Educational Evaluation, 56*, 164–181.

Rodriguez, A. J., & Morrison, D. (2019). Expanding and enacting transformative meanings of equity, diversity and social justice in science education. *Cultural Studies of Science Education, 14*(2), 265-281. https://doi.org/10.1007/s11422-019-09938-7

Siegel, M. A. (2014). Developing preservice teachers' expertise in equitable assessment for English learners. *Journal of Science Teacher Education, 25*(3), 289–308.

Siegel, M.A, Roberts, T.M, Freyermuth, S.K, Witzig, S.B & Izci, K. (2015). Aligning assessment to instruction: collaborative group testing in large-enrollment science classes. *J Coll Sci Teach, 44*(6): 74-82

Siegel, M. A., Wissehr, C., & Halverson, K. (2008). Sounds like success: A framework for equitable assessment – how to revise written assessments for English language learners. *The Science Teacher, 75*(3), 43-46.

Solano-Flores, G., & Nelson-Barber, S. (2001). On the cultural validity of science assessments. *Journal of Research in Science Teaching, 38*(5), 553-573.

Stoddart, T., Bravo, M., Mosqueda, E., & Solis, J. (2013). Restructuring pre-service teacher education to respond to ıncreasing student diversity. *Research in Higher Education Journal, 19*, 1-19.

Suskie, L. (2000). Fair Assessment Practices Giving students equitable opportunities to demonstrate learning. AAHE BULLETIN, 52(9), 7-9.

Tierney, R. (2016). Fairness in educational assessment. In M. A. Peters (Ed.). *Encyclopedia of educational philosophy and theory* (pp. 1–6). Singapore: Springer Singapore.

Vatandaş, D . (2011). Toplumsal cinsiyet ve cinsiyet rollerinin algılanışı. *Journal of Sociological Studies,* (35), 29-56

Vogelzang, J., & Admiraal, W. F. (2017). Classroom action research on formative assessment in a context-based chemistry course. *Educational Action Research, 25*(1), 155-166.

Wall, C. R. G. (2017). Bridging understanding between preservice teachers and diverse students through service-learning. *Teaching Education, 28*(2), 178–193 Doi: 10.1080/10476210.2016.1236784

Yabaş, D., & Altun, S. (2009). Farklılaştırılmış öğretim tasarımının öğrencilerin özyeterlik algıları, bilişüstü becerileri ve akademik başarılarına etkisinin incelenmesi. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi, 37*(37) s. 201-214.

Yang X. (2019). Assessment accommodations for emergent bilinguals in mainstream classroom assessments: a targeted literature review. *International Multilingual Research Journal, 14*(3), 217-232,DOI: 10.1080/19313152.2019.1681615)

Yılmaz, G. (2019). *Seçme sınavlarının engel durumlarına göre madde yanlılığının incelenmesi* (Unpublished Master's thesis), Hacettepe Üniversitesi Eğitim Bilimleri Enstitüsü, Ankara.

Zieky, M. J. (2016). Developing fair tests. In S. Lane, M. R. Raymond, & T. M. Haladyna (Eds.), *Handbook of test development* (2nd ed. pp. 81–99). New York, NY: Routledge.

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