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Bits & Bytes

ETC Educational Technology Council
LEARN. CONNECT. CREATE.

The Alberta Teachers' Association

Bits&Bytes

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IN THIS ISSUE

Message from the President

Ryan Layton

Some years ago at a technology event, presenters shared a number of approaches for integrating technologies into classrooms. Sessions covered such topics as Google Classroom, Minecraft, circuitry and coding, and one presenter caught my attention with a project he brought from home. He constructed a series of Christmas lights that were programmed to turn on and off in various patterns and colours. Like many other people, I had seen similar products in the store, and although creating something from scratch seemed like a lot of work, the idea intrigued me. After the session, I talked to the presenter and expressed interest in doing something similar, but I had no coding experience under my belt. He explained that he had been in my position years ago, but that he liked challenging himself to do new things and encouraged me to do the same.

I thought about this technology event several times since then as I delved into the world of lights and coding. I threw myself into a situation I knew next to nothing about, but I was excited by the prospect of what I could create. Shortly after, I became acquainted with the website www.adafruit.com/ where I have gone on to create a number of little projects involving circuits and programming. Because I knew very little at the beginning, I found myself posting on forums, asking questions and making mistakes, but learning from them.

Lately we have heard a lot in the education field about the mindset of an innovator. What does this mean? How often do we teachers put ourselves in situations in which we need to stretch, learn, grow and shift our perspective? Do we fill out our professional growth plans only because they are a requirement, or do we create plans to improve on our pedagogical passions? Do we seek to try new things and learn from our successes and mistakes? I encourage teachers at all levels to push yourselves throughout the year to learn, grow and find that spark!

I leave you with this thought: an important goal in schools is to encourage a year's growth in each student, but what are you doing to increase your professional practice by one year? Thank you for all you do for the benefit of students across Alberta. All my best to you as we continue the school year in January. §

I encourage teachers at all levels to push yourselves throughout the year to learn, grow and find that spark!

Global Day of Design

Nicole Lakusta

What Is Global Day of Design All About?

Students need to make, build and tinker. Global Day of Design is a one-day event in May that focuses on using the design thinking process in school. The goal is to inspire a transformation in schools worldwide to incorporate design into an everyday practice with students.

In 2016, over 40,000 students from 450 schools (and four continents) participated. Check out this short introductory video created by author and teacher John Spencer at https://goo.gl/eH6mgN.

Go to http://globaldayofdesign.com/ and scroll down to the list of different maker projects and design challenge ideas. Teachers can also search #GDD17 on Twitter, Facebook and Instagram for other project examples. §

Stop Bringing Tinfoil from Home: The Creation of a Makerspace Launch Pad

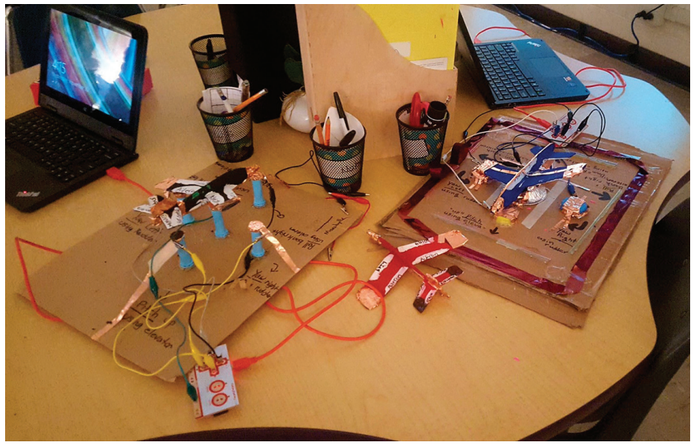
Cory Roffey

"You bring some tinfoil, I will see if I have some cardboard in my recycle bin at home, and then we will see what else the kids can bring," said every teacher ever if they work at a school without a makerspace! The story was the same at St Pius X when the teachers began to explore the idea of constructionist learning. Instead of beginning with a space stocked with robots, wires, cardboard, computers and green screens, we began with a book called *Invent to Learn,* by Sylvia Libow Martinez and Gary Stager (2013), Seymour Papert's (2017) "8 Big Ideas Behind the Constructionist Learning Laboratory," and the idea that the best makerspace is the one between your ears. We focused more on pedagogy and worried less about the physical space. Teachers had kids making on tables at the back of the room, corners of the hallway and once in the boiler room in the basement of the school! They worked with the school-based learning coach, the school-based tech coach, grade partners and cross-grade partners as they explored the pedagogical side of makerspace education. However, once the idea picked up steam in the school, and the lessons requiring tinfoil and cardboard were replacing those requiring paper and pencil, someone uttered the words, "We just need somewhere to keep all this material so we have it when we need it and not always have to bring it from home!" Naturally, the teachers who had been on this journey of constructionist learning concluded that a space to support this type of learning was necessary. We had explored the pedagogical shift and now needed to turn our attention to the physical transformation. We needed a makerspace!

While the pedagogical shift involved in constructionist learning was not easy to make, at least it was relatively cost effective. A few copies of a book to get us thinking and some planning time for good collaborative conversations were minimal expenses for this mindset part of the journey. We knew that the physical shift would be more costly. We also knew that we didn't have the space for a large makerspace room, nor did we want one because we had gotten used to and liked this learning happening at the back tables and under the desks and along the back ledges of our classrooms. Furthermore, one space meant only one class could use it at time and the rest would have to wait for a turn in the week. So after some discussion we decided to apply for an Educational Technology Council (ETC) grant and create a makerspace launch pad. In a nutshell, the idea was to set up a small room that would be stocked with

cardboard, Makey Makey, egg cartons, wires, Raspberry Pi, tinfoil, robotics equipment and so on, but most important we would have bins and mobile carts where teachers and students could load up with all this good stuff and shuttle it back to their classroom to support that great constructionist learning. This way we had the materials and equipment in the building at our fingertips, but the learning could continue to happen in the classroom.

The grant was approved and we set to work. First, we chose a central location so that all teachers could easily access it, which was essentially a storage room. The second and most undesirable step was cleaning out the space. Once we had a suitable empty space, step three involved shelving and storage. We had the option to buy, but we chose to first explore the option of reusing. We hunted for every unused shelf and bin in the building, and after cleaning, repurposing, hauling and organizing, we had a space that was ready for materials, and so far we had proudly spent $0! Since we mostly used consumable items (such as cardboard, buttons and wire), we wanted a lot of them in our launch pad, so after an expert tip from our district emerging technology consultant, we headed to the Edmonton Reuse Centre and returned with a van load of consumable maker materials, and so far our total spent was $5! Our makerspace looked good, and we could have stopped at $5 and had a solid space to launch some great learning from, but in the interest of having tools to think with that can make the most interesting things, we wanted to stock the space further, so we added Raspberry Pi, Ozobot, Makey Makey, and Dash and Dot. These high-cost items allowed students to take their Reuse Centre cardboard, tinfoil and buttons and turn them into amazing demonstrations of learning. Once the space was set up, students and teachers were in and out regularly carrying bins, materials or equipment; wheeling out carts of materials; or looking for that last piece to make the final iteration of their design work. It is a space that has been highly successful in supporting teachers when they want to approach curricular outcomes from a constructionist stance. Most important, no one has to bring tinfoil from home anymore!



St Pius X would like to thank the ETC for the generous grant to support the learning at our school. §

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St Pius X Elementary school is located in Edmonton, Alberta. The school is made up of 400 plus students aged 4–12. The teachers at St Pius regularly use coding and robotics and constructionist learning to uncover curriculum and support students in strengthening learning competencies such as collaborating, problem solving, thinking critically and so on.

Design as a Framework for Innovative Thinking and Learning: How Can Design Thinking Reform Education?

Janis Norman

The University of the Arts in Philadelphia, Pennsylvania

The need for educational reform has led to much research documenting the value of experiential learning and creative problem solving to increase relevance and motivation in learning. Design, which may be succinctly defined as purposeful thought and action, can serve as a framework and catalyst for teaching and learning strategies that promote innovative, high end thinking, cooperative teamwork, and authentic, performance assessment.

This keynote will feature research findings and two models of large-scale applications of design education in the K–12 curriculum. Both projects are funded by major grants from the National Endowment for the Arts and by the Department of Education in the United States. As models of best practices and applied research that have been assessed and documented, they can provide useful and valuable examples for other art educators and educational sites. This research was conducted through the Design for Thinking Teaching Institute, at The University of the Arts, Philadelphia, Pennsylvania, which also was the host site for the National Design for Thinking Network and the Design Link for Teaching the Arts, Link-to-Learn projects. Other sites and research will also be addressed.

As the complexities of our technology-driven society intermix with the erosion of traditional lifestyles and values, it is only natural to look to education for answers on how to prepare children to cope with these new demands. After all, it is the young child who is the most vulnerable and affected by societal changes and, next to parental or family influence, formal education commands the largest block of a child's time and attention for more than a decade of his or her early life.

As educators grapple with their new role and inherited responsibilities, it has become increasingly challenging to find a pedagogical strategy that addresses not only content but context, in a world that is changing faster than our antiquated educational systems can handle. This scenario raises big questions that we must study from a new perspective. What are the basic skills and knowledge that should be the priorities of education? What does an educated person need to know to succeed in a career and daily life? What subjects are most important in the crowded school curriculum? What is the best strategy for teaching critical skills and knowledge? Are the three Rs—reading, writing and arithmetic—still the foundation of our fundamental school system, or are other subjects, including technology, now part of that essential list of content disciplines? The questions are daunting, but even more complicated by the fact that many students have become disenchanted with the value of education, as evidenced by the continually growing dropout rate of 30 to over 50 per cent in the US, especially in our urban and rural high schools. The reason most consistently cited by students who drop out is that school is not relevant to their needs and lives, is often considered boring and, in general, it is often perceived as a negative, meaningless experience.

International awareness of the need for effective educational reform has led to an increased interest in research on the brain and strategies for teaching and learning that are more motivating and relevant to students of all ages. How can students be taught to be more creative in their thinking and more capable of integrating knowledge and skills learned from diverse subject areas into practical and inventive solutions to daily problems? How can learning be more relevant and meaningful, touching the soul of education? What current research can be used to guide this process of educational reform and where will it lead us?

This keynote presentation will share several examples of pertinent and current research findings that point to design-related solutions, followed by a proposed Design for Thinking model, and illustrated by examples of programs that have proven to be effective pedagogical strategies, including two programs from The University of the Arts. Both of these projects were funded by major grants from the National Endowment for the Arts and by the Department of Education in the United States.

Design, as I am using the term, may be succinctly defined as purposeful, problem solving thought and action, or creative thinking and problem solving action, which has no single answer, but may result in one of many effective solutions. Design in education can apply to the discrete discipline, as taught in industrial, graphic, interior, architectural or clothing design, to name a few. In this case it is usually found within the art department as part of that curriculum. However, a second and perhaps even more provocative way of viewing design is in the context of a pedagogical model involving design thinking. This is a more generic application of the thinking that is inherent to the art-related, creative process of invention.

The value of Design Thinking in education is often overlooked for its potential as a dynamic and experiential strategy for teaching creative problem solving; reflective, analytical thinking; and the process of learning to learn.

To examine educational research that is related to the most urgent needs in educational reform, we must first look at the science of learning studies on how the brain learns. This cutting-edge research will profoundly affect teaching and learning strategies in the future, replacing much of the trial and error wisdom, accumulated through years of practice in the traditional classroom. From these studies we will examine a new paradigm that may better accommodate students' physical, emotional and mental needs for the future. Although many educators are reluctant to abandon the familiar practices of traditional instruction, some are cautiously grappling with innovative but unproven elements of reform in hopes of finding a more effective approach to teaching and learning. These educational pioneers are eager to develop new ways of teaching and learning as a modern equivalent to the "Renaissance ideal." This ideal person is one who is able to meet the rapidly changing needs of the information age and the demands for a new kind of educated worker, who is flexible but rational, an out-of-the-box thinker and problem solver. This kind of inventive thinker is a throwback to the Renaissance where an artist also functioned as a designer and creative thinker like Leonardo da Vinci, whose work harmoniously spanned the disciplines of art, science, anthropology, maths and technology.

It is interesting and perhaps insightful that models of creative genius, problem solving, and intellectual and moral balance are often symbolically represented in the work of artists, such as Leonardo da Vinci, Rodin's The Thinker or in the unique architectural creations of Frank Lloyd Wright. For centuries the work of visual artists and designers has been referenced as visible evidence of innovative thinking and brilliance. Yet, ironically, this "design thinking" has never been translated into educational practice. The presence of teaching design in basic education is minimal at best. The value of Design Thinking in education is often overlooked for its potential as a dynamic and experiential strategy for teaching creative problem solving; reflective, analytical thinking; and the process of learning to learn. These attributes are becoming increasingly important as the proliferation of information makes memorization impossible, and in some cases detrimental and inaccurate.

Another pertinent example of educational skills needed in the new workplace is evidenced in the published dialogue of James S Houghton, chairman, National Skills Standards Board, and retired chairman and CEO, Corning Incorporated. In his words,

> The importance of "thinking skills" to the new workplace is evident in the high-performance teams that

Students must learn to selectively process and deal with visual overload and to quickly and effectively evaluate and respond to stimuli that are pertinent and appropriate to their needs and values.

> are today bridging the divide between manual and mental work in corporations throughout America (and globally), handling all facets of project coordination, group dynamics, and consensus building.
>
> (Houghton 1997)

Houghton further refers to another study that revealed the estimate that six to seven million jobs were expected to be created in the US in the last years of the century, but it was also estimated that less than half of those entering the workforce at that time would be equipped for these newly created high-skill jobs (Houghton 1997). Unfortunately, this has proven to be true.

To accommodate the needs of learners today, and in the decades to come, a new paradigm shift is needed for education. In comparing the practices of the 1980s to the emerging paradigm of today, there are dramatically sweeping changes that are being acknowledged as examples of best practices. The new paradigm shift includes the following:

Instruction Versus Construction

Teachers have long relied on the practice of lecture and written content as the primary method of instruction. Students were taught by being told or perhaps shown, but students seldom learned by making and doing, and through their own exploration. Not only has research on learning styles and multiple intelligences promoted the need to expand the modes of instruction, but these findings have also supported the greater effectiveness achieved through the constructivist approach to learning, in which the student pursues an experiential discovery of knowledge by using information in a relevant, hands-on context. This reinforcement of making and doing in a way that is related to personal interests and needs makes the learning experience rich and memorable.

Linear Versus Hypermedia

There are distinct differences in students' interests and habits of learning that can be largely attributed to the influence of television, multimedia and the Internet. The sensory overload and fast-paced bombardment of visual images has affected the students' attention span and habits of learning so that students no longer think and operate only with linear logic and singular focus. Students must learn to selectively process and deal with visual overload and to quickly and effectively evaluate and respond to stimuli that are pertinent and appropriate to their needs and values.

Teacher Centred Versus Learning Centred

The traditional paradigm places the teacher in the role of selecting and directing the discipline content and thematic applications in time blocks he or she thought to be most appropriate. Students were passive learners with little influence in directing their own destiny for learning. In the new paradigm, students determine the context and appropriate ratio for learning in the various disciplines, drawing upon information and skills as needed to complete the interdisciplinary task at hand. Such thematic learning is not only relevant and motivating, but highly effective in empowering the student to take responsibility for his or her own learning process and performance outcomes.

Absorbing Material Versus Learning to Learn

For decades the measure of a student's intelligence was his or her proficiency in memorizing and reiterating facts and information on primarily cognitive verbal and mathematical tests. This process, described as teaching the basics, relied on the assumption that there was an identified and accepted universal cannon of knowledge that was fundamental and comprehensive to each academic discipline. As information exponentially multiplies, it is no longer possible or practical to memorize all the factual knowledge considered basic to any one subject. Students are better served by learning to learn, so that they can ably retrieve and use information in response to a need or an interest. This process emphasizes understanding of information in a relevant context and encourages learners to use metacognition as a process for reflecting on and understanding their own thinking and creative problem solving.

Students value and remember information that is perceived to be useful and relevant to their lives.

Teacher as Transmitter Versus Teacher as Facilitator

In contrast to the teacher as the sage on the stage and primary source of knowledge, the focus is now on student with the teacher as the facilitator of learning. His or her role is to guide and support the student in self-directed research and exploration. This approach individualizes instruction to accommodate students' preferred learning styles and thematic preferences.

Learning for School and Work Versus Learning for Life

Closely related to individualized instructional approaches is the need to customize curriculum content to a real-life context for the learners. Students value and remember information that is perceived to be useful and relevant to their lives. This knowledge then provides a foundation on which they can build over a lifetime, drawing on the skills and knowledge that are needed in an integrated context. This approach is critical to equip students to become lifelong learners, both in a formal academic setting and through professional development in the workplace and home. Learning for life is also congruent with the need to continually learn new information, technology and skills to adapt to the needs of industry and society.

Evaluation Versus Performance Assessment

Measurement of accomplishment in learning information or skills has traditionally been conducted by the teacher with the focus on the effectiveness of the final outcome or product. Rubrics, or guidelines for measurement, were generally set by the teacher or other external sources, with the students having little knowledge or understanding of how their product or answers were graded. In the new paradigm, the emphasis has shifted from product to process, with the analysis of how students learn and progress being perceived as more important than the end result. This concept also assumes that the students will be a part of the reflective assessment process and that they will be charged with the responsibility of articulating what they have learned, what worked and what did not, and why. In answering these key questions, students are required to employ higher order, critical thinking and problem solving, measuring and comparing the outcomes at each stage of development and then ultimately judging the final results in the context of real-life applications. Another benefit of this approach is that it acknowledges that students can learn as much, and perhaps more, from what was not a successful result as they can from an outcome that meets the intended goal. Students can gain confidence and independence by learning to analyze their own learning and from having to articulate and defend their evaluation of the final outcome.

Verbal and Textual Communication Versus Visual Communication

Although dependence on visual imagery to formulate our thinking has always existed, the priority of teaching students to communicate through text has long dominated our educational paradigm. This approach is changing, however, due to the influence of globalization and the competition of visual imagery in the marketplace. As world cultures interact more fluently through physical travel, television and the Internet, the hindrance of not knowing each other's respective languages has prompted the necessity to design international visual icons to symbolically communicate

information. The motivation of conducting business on a global scale has also been a catalyst for accelerating the need to communicate more effectively through the visual medium in both an overt and subliminal way. The sophistication of visual communication and graphics has benefited and been guided by findings in research and brain studies. Scientists, psychologists, artists and designers acknowledge and explore the pervasive nature of visual thinking, which "pervades all human activity, from the abstract and theoretical to the down-to-earth and everyday" (McKim 1980).

In summarizing the focus of the new paradigm for learning, continually changing global access to information through technology, along with the perpetual evolution of research findings, are factors that erode the constructs of basic knowledge, making process rather than product the logical emphasis for students' education. In short, students must learn to learn. By understanding their modes of thinking and developing skills for analyzing a need or intention, they can learn how to define available resources and parameters, explore creative options, plan and organize a potential solution, adaptively produce an outcome, and evaluate the results compared to the set standards of the intention. Optimally the students must also be able to integrate and relate this information with other relevant applications. This is designing! It is also high-end thinking, which draws on both hemispheres of the brain, composites of learning styles and ways of knowing. This is also the attainment of knowledge to the most applicable and memorable degree, and is facilitated by the Design for Thinking model known as I/DEPPE/I (Burnette 1996; Norman 1996).

What students most need to gain from education is the ability to demonstrate higher order thinking, not only on standardized test scores, but more important in the contest of life.

In identifying the desired outcomes of an effective education, the American public and educators are in agreement on one issue: what students most need to gain from education is the ability to demonstrate higher order thinking, not only on standardized test scores, but more important in the contest of life. This goal for achievement in life is measured more broadly in the quality of how people work, play, interact and live in our global and increasingly visual, high-tech society. As committed educators who strive to engage students, provide practical, relevant skills and help them creatively integrate knowledge in the context of future careers, perhaps we need to rethink the Da Vinci model. Research studies support the strategies and processes used in art and Design Thinking as skill developers critically needed to hone the desirable characteristics of humanity—to think, reason, communicate and create innovative and appropriate solutions.

In this "decade of the brain," recent psychological and neuropsychological research provides a growing body of scientific evidence and related literature, which could inform and influence how art education is designed. Numerous studies support and identify the attributes of a strong art and design education for developing the skills of creative and analytical thinking, perceptual sensitivity, perseverance, communication and inventive problem solving. Among the most provocative of the research studies is the work of Howard Gardner, related to his theory of multiple intelligences. His definition of intelligence is "the ability to solve problems, or to create products, that are valued within one or more cultural settings" (Gardner 1983). Having initially identified seven, now eight and a half, comprehensive categories for intelligences, he adamantly describes each as being distinct and definitive. Included in these are spatial and bodily kinesthetic intelligences, which are deviations from the commonly perceived idea of intelligence as a blend of logical-mathematical and linguistic abilities. These art and design-related ways of learning recognize the unique characteristics, which are inherent in art making and design thinking, and the benefits and importance of cultivating the full range of cognitive, affective and psychomotor skills.

Design thinking is a term defined by consensus in the National Design for Thinking Institute (August 1998), supported by the National Endowment of the Arts, attended by designers, architects, administrators and educators in higher education, K–12 art and general education. The institute also included directors of art and design-related museums, representatives of departments of education, as well as editors of two national magazines and an educational publishing company. After analysis, discussion and careful weighing of each word and its meaning within the context of the design process, the following definition was adopted: Design Thinking is an inventive process, through which problems are identified, solutions proposed and produced, and the results evaluated. This concept of design is also based on the underlying principles of art making with practical application. Succinctly stated, it is purposeful, problem-solving thought and action (Burnette 1996; Norman 1996).

Design Thinking is an inventive process, through which problems are identified, solutions proposed and produced, and the results evaluated.

Another thought-provoking interpretation of design is provided by David Perkins in his book, *Knowledge as Design* (1983). Perkins describes design as "a structure adapted to a purpose." He further explains that "knowledge as design poses a provocative metaphor. Indeed, perhaps knowledge is not just like design but is design in a quite straightforward and practical sense." Acknowledging that higher order thinking and integration of information into a relevant context are part of the design process, Perkins' metaphor offers a compelling argument for the value of incorporating Design Thinking into the fundamental educational curriculum.

Intelligence, not unlike design, is also an ambiguous term with multiple meanings and interpretations. Both words are used to describe aspects of human uniqueness and function that are fundamental and essential to our very survival. The confusion that clouds the two terms, *intelligence* and *design*, stems in part from the definers' personal perspectives and experiences, which, in turn, colour their meaning and context. The interpretations are further hindered by our limited human knowledge about the rather magical processes of complex creative thinking and related human feelings and actions. We are still mystified by our ability to reason, to invent and to solve problems at all levels in our daily lives and are consequently uncertain as to how to facilitate that level of learning.

Ironically, it is the characteristics of creative design and intelligence that distinguish humans from other animals, and yet we have much to learn about how these processes are cultivated and impacted by teaching and learning. The knowledge base to inform our teaching practices is expanding, however, with educational researchers adapting findings of brain research to theories of educational philosophy and applied practice (for example, Bogan 1969; Gardner 1982, 1983; Jensen 1998; and Sylwester 1995). Concepts such as multiple intelligences, brain-based or brain-compatible education are direct manifestations of this hybrid of neuroscience psychology and educational research, with some studies focusing more specifically on discipline domains, such as art and design.

As educators across our nation contemplate options for more effective teaching and learning, the science of learning and the influence of brain research are of paramount importance in setting priorities, policies and pedagogical practices. This is true for all levels and disciplines, including design. However, to put theory into practice with effective results, teachers must be flexible learners and risk-takers, who are facilitators of knowledge and who coach and promote high-level thinking using all forms of creative intelligence.

Design for thinking is one model for investigation and exploration of multiple creative solutions. The I/DEPPE/I acronym, which stands for intending, defining, exploring, planning, producing, evaluating and integrating, is basic and practical as a tool for learning both with individuals and groups. With groups it can facilitate team building and group consensus.

The design for thinking model, initiated at The University of the Arts in Philadelphia, Pennsylvania, is based

on more than a decade of intense and sustained studies of Design Thinking and ways it can be effectively applied to the education process. A sequence of projects have led to major sponsorship by the Department of Education for two consecutive grant projects based on the design for thinking, I/DEPPE/I model, as developed and implemented through technology. The first of the two projects was Design Link for Art and Science, which involved four testbed middle schools, an art museum, a science museum and university faculty in a collaborative effort to apply the design for thinking model to the teaching of art and science using electronic media, the Internet and video conferencing technologies. As an infrastructure investment grant, the one-year project required development, technology training, classroom application and assessment.

The Design Link for Teaching the Arts project, which overlapped the Design Link for Art and Science project in the planning phase, built on the foundation of the previous project. It continued partnership with the four schools and it added museums and an instructional unit from the Pennsylvania Department of Education, which serves many schools in the rural, mountainous northeast portion of Pennsylvania. Retaining the "mentor teaching teams" from the original four testbed schools, the project expanded to include five additional urban schools in the Philadelphia area and eight rural schools in the northeast, mountainous part of Pennsylvania. Participating teacher teams from a total of 17 schools were provided with regular biweekly professional development classes and additional online support to help them learn and apply the I/DEPPE/I, design for thinking model, facilitated by technology, and focused on ways in which the arts could be integrated into the curriculum. In addition to the emphasis on professional development for K–12 teachers, the project also provided regular instructional sessions and teaching mentorship for college education faculty and the preservice teachers in art education. Curriculum was developed and implemented for each of these groups, and large and small-scale assessment was conducted to measure the impact and effectiveness of Design Thinking and technology in teaching and learning.

The assessment of both of these projects yielded similar results. Both teachers and students found technology and the design for thinking model to be motivating, a facilitator to interactive, cooperative learning, and helpful in organizing thought and actions. The challenge of not fully understanding and knowing how to use either was daunting at first but became more comfortable as they progressed. Ultimately, they felt that both design and technology were critical to their teaching and learning in the new paradigm and endorsed their inclusion strongly with comments such as the samples below:

> Although challenging, this experience has taught me a lot regarding the benefits of project-based learning, team-teaching, and continuously assessing work based on teacher, peer, and self-evaluation (teacher assessment, Design Link for Teaching the Arts, 2000).

This program has really focused on "process." I so appreciate the I/DEPPE/I model and it was a key teaching tool for me this year. Students have constantly referred to it and often point their peers back to the model when something doesn't work out in a scene or presentation. At last, something that is complete, simple and applicable. (theatre teacher assessment, Design Link for Teaching the Arts, 2000)

In the first grade, the I/DEPPE/I model was utilized by asking questions pertaining to each letter, since this was the first introduction. The art project with the students went well with wonderful results. (first grade teacher assessment, Design Link for Teaching the Arts, 2000)

To quote an anonymous statement by a Philadelphia high school music teacher who learned and used the model in this past year:

> The (I/DEPPE/I) model was the best part of the program for me because I could take the critical thinking model right back to my class in everything we did. The students started to call it the "peanut butter and jelly" (basic structure for how to learn) model! Our final project was to design a musical that addressed teenager issues. The students worked in five teams and developed their musicals based on the model. They wrote and rewrote, they rehearsed and performed and completed their pieces. They evaluated the process and expressed how they would incorporate it in future work. At last! A technique that makes sense of learning.

Design, when taught within the structure of the design for thinking approach, is a means of creative problem solving that relates thought and action in a very direct and dynamic way. It involves the exploration of needs and functions to be considered; the context in which the problem exists; the audience or participants to be served or affected; the scope of the results you wish to achieve; and the means of evaluation that will measure the solution's effectiveness, either through conscious or unconscious judgment. Design, a visual art form with a practical outcome, offers a means of conceptualizing and visualizing, from problem to solution, a process essential to learning in life. §

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Transforming Constructivist Learning into Action: Design Thinking in Education

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In an ever-changing society of the 21st century, there is a demand to equip students with meta-competences going beyond cognitive knowledge. Education, therefore, needs a transition from transferring knowledge to developing individual potentials with the help of constructivist learning. Advantages of constructivist learning and criteria for its realization have been well determined through theoretical findings in pedagogy (Reich 2008; de Corte, OECD 2010). However, the practical implementation leaves a lot to be desired (Gardner 2010; Wagner 2011). Knowledge acquisition is still fragmented into isolated subjects. Lesson layouts are not designed efficiently to help teachers execute holistic and interdisciplinary learning. As is shown in this paper, teachers are having negative classroom experience with project work or interdisciplinary teaching due to a constant feeling of uncertainty and chaos as well as lack of a process to follow. We therefore conclude that there is a missing link between theoretical findings and demands by pedagogy science and its practical implementation. We claim that Design Thinking as a team-based learning process offers teachers support toward practice-oriented and holistic modes of constructivist learning in projects. Our case study confirms an improvement of classroom experience for teacher and student alike when using Design Thinking. This leads to a positive attitude toward constructivist learning and an increase of its implementation in education. The ultimate goal of this paper is to prove that Design Thinking gets teachers empowered to facilitate constructivist learning in order to foster 21st-century skills.

Introduction

The mandate of schools is to unfold the personality of every student and to build a strong character with a sense of responsibility for democracy and community. This implies developing skills of reflection, interpretation of different information and other complex meta-competences. Science, business and social organizations alike describe a strong need for a set of skills and competences, often referred to as 21st-century skills (for example, Pink 2006; Wagner 2010; Gardner 2007) or key competences (OECD). These include communicative, social and creative meta-competences in addition to cognitive skills (Carroll et al 2010). Schools are the only compulsory place for most young people to develop abilities and qualifications. Therefore, educational systems are getting more and more demands to facilitate the development of such competences and skills. With the complexity of everyday life increasing, globalization, fast-changing technological advances, product cycles getting shorter and economic competition tightening, innovative capacities comprised in the 21st-century skills have become crucial for individuals to survive in an ever-changing society (Dikmans 2011). Most of them are related to knowledge management, which include processes concerning information selection, acquisition, integration, analysis and sharing of knowledge in socially networked environments (de Corte 2010). It is important to equip not only academics with those skills at university but also students in schools.

Content learning is important, but in order to effectively internalize knowledge, metacognitive competences, attitudes, values and action skills are crucially necessary (Weinert 2003). Teaching such metacognitive competences need to go beyond isolated information acquisition in certain subjects, toward a holistic learning through experience and reflection in projects. So-called CSSC learning, which enables learning processes that are constructed, self-regulated, situated in real-life context and collaborative (de Corte 2010) is recommended by educational experts. The questions intrude: what does a format look like that successfully implements CSSC learning in the school context? How is phenomena made understandable as a whole, going beyond their fragmentation into mono-disciplinary subjects? How is complexity accounted for rather than focusing on isolated parts of knowledge? We believe the crucial point is to get teachers motivated and enabled to effectively implement CSSC learning, acknowledging side effects of projects like chaos and crisis as learning opportunities. It is necessary to equip them with tools and methods, which create a positive classroom experience while exercising project work. We furthermore claim that Design Thinking can serve as such a format. Design Thinking, here defined as a team-based learning method, helps to deal with complex problems by sustaining in-depth learning processes on problem perception and diverse solution paths (Kröper 2010).

The objectives of this paper are to synthesize research on issues related to constructivist learning theory and teaching design, to identify problems of realizing CSSC learning in the school context, and to offer a solution to meet those difficulties with the use of Design Thinking in order to facilitate and foster constructivist teaching and learning in the school context (for example, high school). Here are the research questions: Can the facilitation of CSSC learning be advanced using Design Thinking? What is the classroom experience like when using Design Thinking? Is the use of Design Thinking valuable for the teacher?

The Claim on Education: Developing 21st-Century Skills Through a Constructivist Learning Design

From educational researchers to businesspersons and politicians, society is calling for so-called key competences in order to be able to deal with any sort of complex problems that dominate all facets of our society and business world (Pink 2010, Gardner 2010).

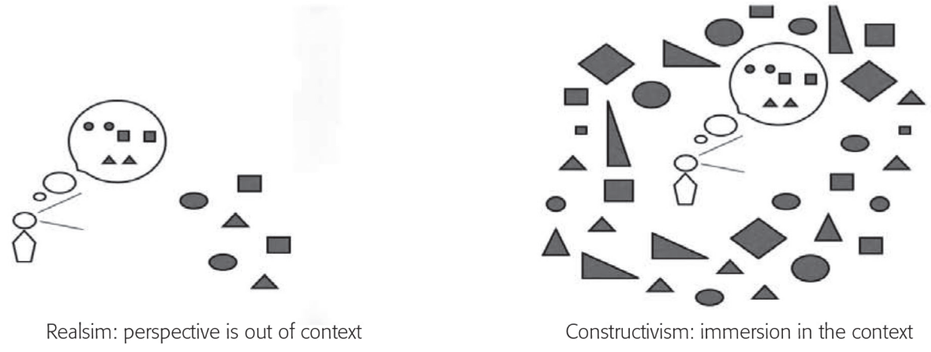
Those key competences involve knowledge, skills, attitudes and values (Weinert 2003). Harvard professor Tony Wagner calls them the "seven survival skills for careers, college, and citizenship" (Wagner 2011):

- Critical thinking and problem solving
- Collaboration across networks and leading by influence
- Agility and adaptability
- Initiative and entrepreneurialism
- Effective oral and written communication
- Accessing and analyzing information
- Curiosity and imagination

Pedagogy science states that such accounts can be met especially well through a holistic constructivist approach (Weinert 2003; Knoll 1993; Reich 2008). One method is learning in interdisciplinary projects (Dewey 1913). In constructivism, learning is a process of individual self-organizing knowledge. The process of learning is unpredictable, and knowledge constantly altered through new insights, which are gained through individual experiences (Reich 2008; Kolb 1984) as opposed to realism, in which the learners are regarded as independent observers of objects. In contrast, constructivism integrates learners within their own observations in a cycle of creation and observation. An interactive relation between the observer and the observed arises (for an easier understanding see Figure 1). Educationalist and philosopher John Dewey regarded the interaction between the subject and the world with all its complexity as essential for gaining knowledge. Dewey's understanding identified learning as a multifaceted process of structured interaction of humans with their natural and social environment. These interactions produce experiences that modify further interaction.

"There is no me without us" (Dewey 1931, 91). Perception and knowledge only develop in relation to and through interaction with the object and its context. Therefore, learning in the constructivist perspective is a process of constantly adapting to situations, which consist of ever-changing relations between subject, object and context. However, constructivism is neither a method nor a universal model, and it does not provide concrete didactic indications for the teacher to implement.

In contrast to constructivist beliefs, education today is centred on specific disciplines and isolated subjects, which is the result of breaking down a complex real-life phenomena into little parts. Small information parts are easier to absorb for the student. Concentrating on one aspect of phenomena and distributing knowledge rather isolated from its complexity might be better manageable for the teacher. However, this disregards that the whole is different from the sum of its parts. In addition, splitting up a complex phenomenon into subjects and only examining isolated facts makes it hard for the student to recognize links between facts and phenomena. A connection to the real-life context is missing. However, theoretical findings about the advantages of constructivist learning (that is, the holistic



Realsim: perspective is out of context

Constructivism: immersion in the context

FIGURE 1.
The learner and his environment, Andrea Scheer 2011

approach, real-world challenges, motivation) and criteria for its realization are distinct (Reich 2008; Dewey 1916). The practical implementation itself does not yet take place effectively (Gardner 2010; Wagner 2011). We believe that teachers are demotivated and helpless in making use of constructivist learning theory and realizing holistic project work in the classroom, due to negative classroom experiences with project methods. This is partly because of difficulties in assessing performance in project work. It will always be easier to let students do a test, asking for logical and analytical thinking only (computer-like). These tests are linear, sequential and time restricted. It's still difficult to measure more complex and social-oriented 21st-century skills. Still the old saying is true: What you test is what you get. Ministries of educations therefore take this issue seriously right now. Over the last years, there has been a big effort in many western countries to integrate 21st-century skill assessment into major, mostly centralized tests, as the A-level or German *Mittelstufenabschluss*. This is still a struggle but has already proven to open the education systems to a new group of students, focusing on those with actual potential, regardless of their educational background.

Another reason might be missing recommendations of designing constructivist learning and project work. The latter shall be in the focus of this paper. There is a missing link of transferring theoretical findings of pedagogy science into practical implementation, which leads the teacher to focus on approved and easily conductible content learning methods, denying constructivist learning projects. Wagner refers to it as the "Global Achievement Gap," the gap between "what even the best schools are teaching and testing versus the skills all students will need for careers, college, and citizenship in the 21st century" (Wagner 2011). We want to fill that gap by proposing Design Thinking as a meta-disciplinary methodology that offers teachers the needed support through a formalized process. Teachers, as facilitators of learning, need to be equipped with up-to-date skills and tools to actually practise on the needed key competence learning. Otherwise, there is a risk that such competences will decline even more. There are high stakes in teacher education.

Criteria for a Constructivist Learning and Teaching Design

Learning is a process of understanding, which leads to modifications in the behaviour of the learner (Hasselhorn and Gold 2006). According to constructivist theory, this is achieved through experience. The teacher as a facilitator of learning should consequently be able to design learning experiences. So, what is needed for constructivist learning design? In his concept of CSSC learning, Erik de Corte points out four main criteria for competence-oriented learning: to be constructed, situated in context, self-regulated by the learner and collaborative (de Corte 2010). As participation and engagement of the student is a crucial characteristic of constructivist learning (Reich 2008), the teacher needs to involve the student in the learning design, for example, to look at the students' interests in order to propose a problem statement or project challenge. Even more so, they need space to try out different mental models and methods to connect abstract knowledge with concrete applications and thereby being able to convert and apply abstract and general principles (acquired through instruction) in meaningful and responsible acting in life (acquired through construction).

The following three aspects are essential for a convenient constructive learning design:

- Involvement of students
- Experience space
- Balance of instruction and construction

In sum, a good lesson design needs to be a balanced composition of instruction and construction, or as Dewey would say "construction through instruction" (Dewey 1913; Knoll 1993). A lesson design should answer *how* students can experience certain situations and how teachers can enable this experience. Schools mostly failed at good learning designs until today. The how, for example, the instruction to execute constructivist learning, is either too open (free construction only) or too detailed (instruction only).

Teaching Complex Phenomena—Approaches for Implementation

ABSTRACT APPROACH: DEWEY'S PROBLEM-SOLVING METHOD

Dewey's understanding of learning was a direct process of a structured interaction of humans and their natural and social environment. These interactions produce experiences that modify further interaction (Dewey 1913)—learning took place (see definition of learning above, [Hasselhorn and Gold 2006]).

Thinking and doing are very much intertwined as one defines the other and vice versa. This reflects a holistic process of thinking and doing as education. Dewey suggested a method of constructive problem solving. Dewey's method centres on an inquiry in context unfolding a problem or difficulty, which then motivates for further analysis and exploration. New insights are the foundation for an explanation of that inquiry and are followed by a plan of action to solve the problem according to the explanation.

The following criteria are needed to realize this method:

- Challenges situated in the learner's real-life environment
- Action—interaction of thinking and action plus interaction and sharing of knowledge between learner and teacher
- Application—solving the problem and applying the insights, reflecting and understanding through applying ideas

In conclusion, Dewey's perspective on learning and education centres on a real-life inquiry, which has to be analyzed in its complexity. The inquiry acts like a magnet for content, it motivates further analysis of content and input of several disciplines in order to explain and solve that complex inquiry as a whole (Dewey 1931). In that, the Dewey approach meets the main aspects of constructivist learning. It involves the student throughout the learning process, suggests balancing instruction and construction, and more or less allows experience in real-life situations. Although Dewey described his method theoretically, the complexity and abstractness of these recommendations are the crux of the matter for teachers to implement them in schools. His recommendations are not enough to get over the difficulties of teaching complex phenomena in a holistic constructivist manner. That might be why education today still focuses on breaking down complex phenomena into smaller, isolated subjects. This is because they are easier to implement and distribute to students in the first place. This is why we compared Dewey's method to Design Thinking, as we believe that Design Thinking can give concrete recommendations for distributing a complex phenomena without abstracting too much, but still being digestible for the student and implementable for the teacher.

Concrete Approach: Design Thinking in Education

Design thinking understood as a meta-disciplinary methodology loosens the link to design as a

> profession. Even though Design Thinking was explored and developed in connection with professional designers at first, strategies have been identified that are relevant to all disciplines and professions. (Lindberg et al 2009, 4, emphasis as per original)

Thinking like a designer involves different kinds of abilities and competences in different fields of knowledge: conceiving, planning and making products (Buchanan 1999). Those are cognitive processes manifested in design action. Designers are used to dealing with complex problems, and by generating diverse high-scoring solutions, analyzing and evaluating them in order to gradually improve them (Dorst 2006). This is what students should be enabled for and what the so-called key competences are all about: dealing with complex real-life problems by analyzing and evaluating them in order to act solution oriented and responsible. Design Thinking realizes what is recommended theoretically in constructivist theory. Especially learning through experience and complex problem solving among other aspects are met in Design Thinking and can be employed at all age groups, for example, extensive experiences at the K–12 program at the d.school in Stanford, USA. Design Thinking is a constructivist learning design because of its qualities in training certain skills, which are predispositions for a constructive way of learning: motivation for exploration, openness for new ideas, creative thinking and other metacognitive competences (Noweski 2012). In a Design Thinking context as described in the phases below, such predispositions are met to ensure 21st-century skills development. Students are motivated for exploration, trust is built up between student and teacher to give confidence for self-exploration, and team competences are fostered to express one's opinion and share knowledge. A formalized process guides the teacher toward constructivist learning. Design Thinking can be realized in short sessions integrated in a highly specialized A-level biology class, as in interdisciplinary full-project weeks.

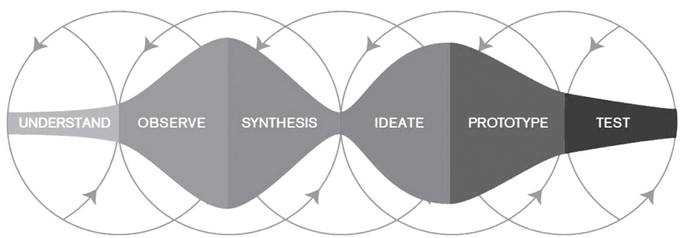


FIGURE 2.
Design Thinking Process, author unknown

Pioneering this approach, the Nueva School in California states that Design Thinking is taught, applied and explored in three strands:

> Some projects aim to take students through the entire design-thinking process. These experiences include a Secret Service project, (kindergarten), Cooperative Games project (Grade 2), year-long Design Engineering classes, (Grades 4–5) and the Solar House project (Grade 6). Integrated projects require students to use aspects of the design-thinking process as tools to solve real problems presented in homeroom or subject classes. These include STEM projects like Electrical Switches (Grade 2), Catapults (Grade 5), Roller Coaster (Grade 6) and Cell Membranes (Grade 8). They can also include social problem-solving activities like the Service Learning Fair (Grade 3) and the Social Issues project (Grade 5), and art projects like the Electronic Arts and Digital Storytelling electives. Other pursuits involve independent exploration. Individual students, clubs and teams use the school's design-thinking and engineering resources to deepen their own skills during recess, electives and the after-school program. Projects have ranged from designing model houses to robotics competitions. (Nueva School, Design Thinking Overview)

The Design Thinking process fosters several competences in different phases, in which expansion and consolidation take turns. This is the heartbeat of Design Thinking. The phases are as follows:

Understand and Observe (Expanding)

The first step in the design process is to build up empathy and understanding of the people and the situation the problem or challenge is set in. The goal is to get a clue of relations between the problem and its context, and to find out hidden needs. Empathy is the competence of recognizing feelings, thoughts, intentions and characteristics of others.

Synthesis (Consolidating)

In order to solve a problem and generate meaningful ideas, one has to define the problem and its context. As seen in the phase of understanding, there are different perspectives on one particular problem and a lot of information is generated to describe the problem. In the synthesis phase, all this information needs to be interpreted and condensed to meaningful insights, in order to be able to generate actionable solutions. It involves critical thinking and interpretation skills to condense a lot of information into a compelling point of view and clear direction for ideation.

Ideate (Expanding)

Ideation means opening up the mind, being imaginative and generating lots of ideas for solving the problem. Brainstorming in the team helps to build on the ideas of others and collaboratively transforming the knowledge about the problem and its origins into actionable problem-solving ideas. This is what pedagogy describes as the competence of applying knowledge.

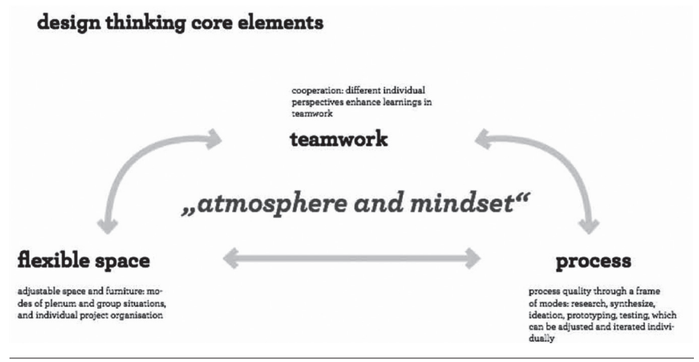


FIGURE 3.
Core elements of Design Thinking, Elias Barrasch 2012

Prototype (Consolidating)

The prototype phase is all about experimentation to bring ideas alive, to make them tangible, actionable, testable and learning more about the ideas, its possibilities in form and function through building them. The goal of prototyping is to be able to share ideas with others, to specify your abstract imaginations and to get the mental concept of an idea into the physical world.

Test (Expanding)

Testing means bringing the idea, the solution generated through the design process, into action to get feedback on which to build on from other persons, experts, novices, users and everyone involved in the problem context. Through testing, a lot of information is gathered, in that it is similar to the observe-and-understand phase. However, this information focuses on the solution and shows how well the problem has been understood. It is important to be able to communicate the idea you want to get feedback on, and to capture and interpret that feedback in order to refine your idea.

Iteration

The process follows these six steps that build on each other while preserving a cyclical and iterative nature. The star's outer lines and imagined arrows illustrate that it is possible and desirable to move from one phase to any other at any point of time, as well as to repeat the whole process or certain stages. The testing phase already implies a smooth transition to the observing and understanding phase, as the problem context has changed with your idea. Its iterative nature unfolds the whole concept of constructivism—there is no such thing as a fixed and one-dimensional reality, rather different situations apply different perspectives and new perspectives generate new situations. Knowledge is individually self-organized and proofed in and adapted to the context.

FIGURE 4.
Design Thinking Workspaces in the classroom, Fabian Schülbe 2011

Design Thinking comprises three core elements (Figure 5), flexible space, teamwork and the design process, into a systemic approach on problem solving. In that, it is not only a process of learning but a whole mindset and atmosphere.

There is a high degree of student involvement as Design Thinking is constantly giving opportunities for experiencing complex phenomena and reflecting on insights. A balance between instruction and construction is accomplished through the iterative manner of the learning process.

As theoretically described, Design Thinking as a formalization of constructivist learning fosters the development of 21st-century skills and is a method for team-based learning in holistic projects. In our case study the success of realization of Design Thinking in a school context and its usability for teachers was tested.

- Do students like to work with Design Thinking and do they actively participate?
- Do teachers like working with Design Thinking and are they likely to use this method again?
- Does Design Thinking build up a positive learning atmosphere between teacher and student?

Case Study

Design Thinking was tested with Grade 10 high school students (aged 15–17: Grade 10 is the last general school year before college in Germany) in order to analyze and evaluate Design Thinking as a teaching method in comparison to Dewey's recommendations. The students' and teachers' motivation, the learning atmosphere and the development of cognitive and social competencies were the main criteria for analysis. An empirical study was set up to prove the above stated hypotheses with the use of quantitative questionnaires and the *Inventory of Social Competence—ISK* (Kanning 2009). A three-day case study took place in a secondary school in Potsdam, Germany, involving 125 students and a team of 12 teachers and coaches (assigned by coincidence). Dewey groups were schoolteachers. Design Thinking groups were coached by d.school coaches. All the coaches were chosen to have similar characteristics (end 20s, highly motivated, open for new methodologies and experts in their domains, project teaching with students/Design Thinking coaching, participated in a briefing to make sure their knowledge level of the methods were equal). The students were divided into 22 teams of five to six students each to face the real-world challenge "New Media in the Classroom—How Can We Help Teachers to Use New Media Efficiently in the Classroom?" The Design Thinking process, as described above, was used by eleven teams. One Design Thinking coach was facilitator for two teams. These eleven Design Thinking teams were compared with eleven teams using the project-based method (Kilpatrick 1918). One teacher was facilitator for two teams in this experimental category. The coaches were prepared in a training session. Here, they got information to intensify their already existing knowledge on their pedagogical approach. When the students arrived in the morning, we told them which teams they had been randomly assigned to, ensuring that gender and classes were as equally dispersed as possible. There was a facilitator for each room (six teams), supporting the teacher and students with organizational and methodological difficulties, but the main challenge was left to the coaches and students themselves. They knew their challenge, the timeframe and the method they ought to use, and all of them were told to have as much fun as possible. All teams were set in an ordinary classroom of the high school (six teams per room) and equipped with whiteboards, bar tables and stools, working-, research- and prototyping material, as well as one laptop and a beamer for presentations.

Every day students and teachers had to fill out several questionnaires, but spending no more than 20 minutes per day on them, except for the *Inventar Sozialer Kompetenzen—ISK*

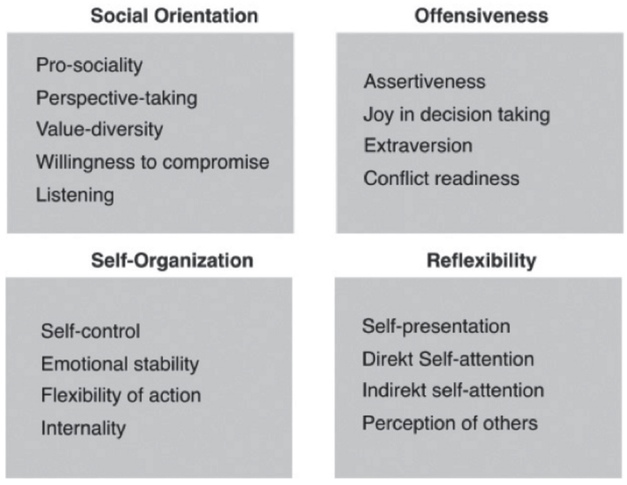


FIGURE 5.
Scales of the Inventar Sozialer Kompetenzen, based on Kanning 2009

(Kanning 2009, see chapter III: How Does Design Thinking Contribute to Developing 21st-Century Skills?), which was filled out by the students in their regular class settings before and after the workshop. To see what impact the workshop had—if any—on the social skills of students, pre-post comparisons (that is, gain-scores) were calculated. In sum, students of the Design Thinking condition profit more than students of the Dewey condition. Even though not all differences in gain-scores are large enough to reach statistical significance, the picture is consistent: In an 18 out of 21 scale the gain scores are more favourable for Design Thinkers. In particular, the gain scores differ with statistical significance ($p < .05$) on the following scales, favouring Design Thinking: Self-Expression, Direct Self-Attention, Self-Monitoring and Reflexibility. Close to significant ($p < .1$) are differences of gain scores on the following scales: Assertiveness, Flexibility of Action, Indirect Self-Attention and Person Perception.

Results

Design Thinking fosters metacognitive skills and competences explicitly by using a formalized process. Such a process offers the teacher support in realizing constructivist learning and gives recommendations for methods (for example, method for effective reflection, brainstorming rules). As described in the theoretical part above, Design Thinking projects focus on constructivist learning and integrate content. What is crucial in Design Thinking are the process phases that need to be run

through. The teacher can put different emphasis on different phases, according to the learning goal and individual needs. But only the process as a whole with all its steps sets the frame for constructivist learning. Encountering new content and complex interrelations of information, solving team crisis and getting feedback for intermediate results are difficult aspects of such project-learning but also crucial for developing metacognitive competences. This is realized through the Design Thinking process as a whole or as Dewey would point out the whole act of thinking. With the process on hand, the teacher is prepared for these challenges, being confident in solving them and thus more motivated in using the process and actually realizing constructivist learning. In that, Design Thinking serves as a first standard for constructivist teaching regardless of the scope of ambiguity of teacher motivation. Once succeeded in the process (solving of challenge, mastering the process), the teacher gets positive feedback, and the development of students' social competences can be assessed (Noweski 2012). This success leads to motivation of both students and teacher in realizing more constructivist learning.

1. Teachers describe the students as more participatory than usual at school if a constructivist teaching method is applied.

Question answered by teachers: How did the students come across throughout the workshop?							
	-3	-2	-1	0	1	2	3
	☐	☐	☐	☐	☐	☐	☐
more interested than normally at school							less interested than normally at school
more receptive than normally at school							less receptive than normally at school
less independent than normally at school							more independent than normally at school
more friendly than normally at school							less friendly than normally at school
less engaged than normally at school							more engaged than normally at school
less emotionally involved than normally at school							more emotionally involved than normally at school

FIGURE 6.

Average teacher judgments regarding the question: "How did the students come across throughout the workshop?" rated on a scale ranging from -3 to +3; negative values indicate the left characterization applies more; positive values indicate the right characterization is more applicable.

2. Teachers consider Design Thinking a highly valuable teaching method—more valuable than the Dewey approach.

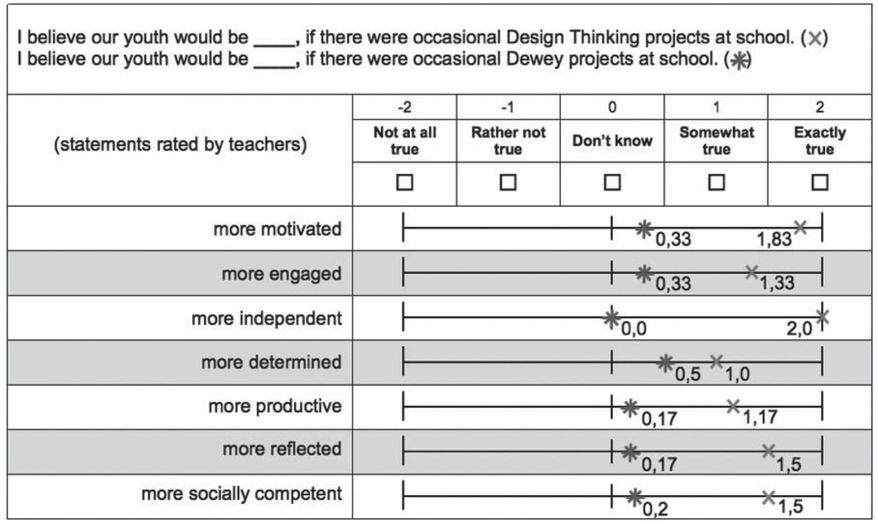


FIGURE 7.

Average teacher judgments regarding the expected impact of Design Thinking or Dewey's project work at school.

3. Teachers state they are very likely to pursue a Design Thinking project if possible. Whether they would carry out a Dewey project is much less certain.

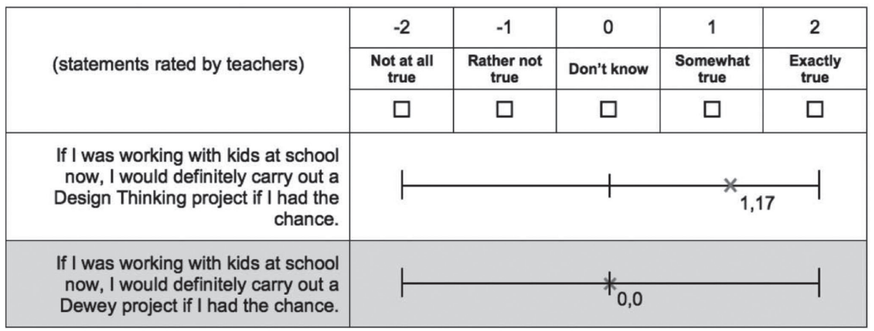


FIGURE 8.

Average teacher statements regarding whether or not they are likely to carry out a Design Thinking or Dewey project at school.

4. The teacher–student relation is positive in Design Thinking and in Dewey projects. In Design Thinking projects, it is even more positive than in Dewey projects and consistently so.

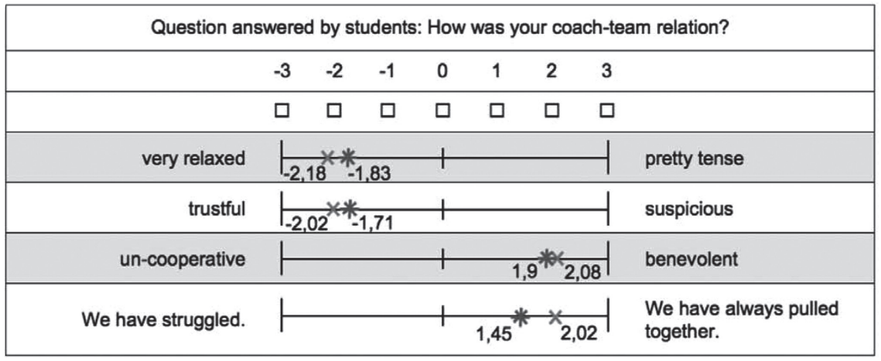


FIGURE 9.

Average student ratings of coach–team relation in Design Thinking (×) versus Dewey (*) projects.

5. Students appreciate the Design Thinking and the Dewey method. Consistently, they value the Design Thinking method even more than the Dewey method.

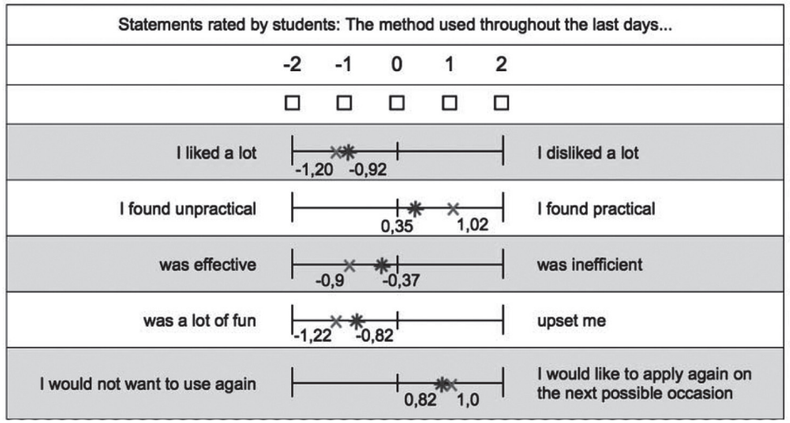


FIGURE 10.

Average student ratings regarding the Design Thinking (×) versus Dewey (*) method.

6. **Mood assessment.** On each workshop day students and coaches specify their mood: in the morning, at midday and in the afternoon. The mood scale ranges from -10 (extremely negative) to +10 (extremely positive). There is one additional point of measurement for coaches due to their day of preparation ahead of the workshop.

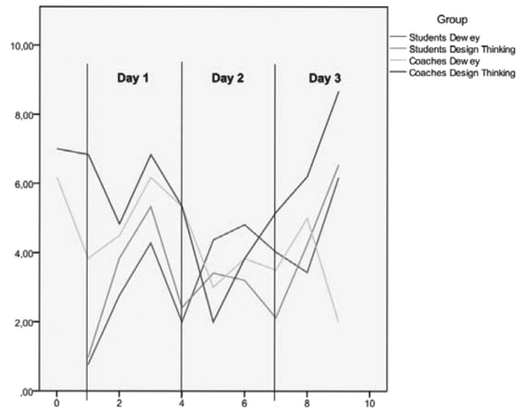


FIGURE 11.

Positive sentiments.

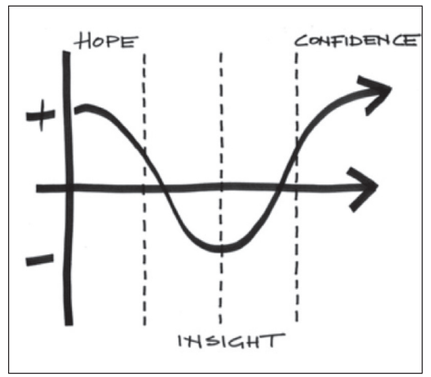


FIGURE 12.

Development of teacher motivation, Mia Konew 2011

Students and coaches report positive sentiments throughout the whole project. Indeed, at each single point of measurement all four groups (students Dewey, students Design Thinking, coaches Dewey, coaches Design Thinking) report an average mood in the positive realm (above zero).

Daily trends. At all three project days there is a trend that the mood improves from morning to afternoon.

Final sentiments. Students leave the workshop with a very good sentiment both in the Dewey and in the Design Thinking condition. For the coaches, an immense difference becomes apparent: The mood of Dewey coaches drops drastically while that of Design Thinking coaches takes off.

Conclusion

The impact of Design Thinking in teaching and learning at schools is promising. The case study has resulted in a positive experience for the participants. Design Thinking gives teachers faith in their creative abilities through a process to hold onto when facing difficulties during the project. We can conclude that our hypothesis confirmed that a teacher would be more likely to repeat constructivist teaching in a real school scenario when applying the Design Thinking process. This was mainly evaluated through measuring the self-perception of teachers (mood measurement, questionnaire). In further research, external evaluation could be applied to enhance the results. As can be seen in Figure 12, the ambiguity of the teachers' personality at the beginning of a project still relies on openness (hope) toward constructivist teaching. Nevertheless, Design Thinking can give especially critical minded teachers a guiding framework and support until dynamic sets up, motivating and leading to confidence.

Design Thinking can serve as the missing link between theoretical findings in pedagogy science and the actual practical realization in schools. It meets the crucial criteria for effective 21st-century learning by facilitating interdisciplinary projects, approaching complex phenomena in a holistic constructivist manner. It thereby leads to a transition from the transfer of knowledge to the development of individual potentials. It enhances the implementation of CSSC learning by giving teachers more confidence in creating and exercising collaborative project work.

Furthermore, Design Thinking fosters a positive relationship between teacher and students. In addition, the corresponding paper by Noweski (2012) confirms the fostering of students' social and metacognitive competences through Design Thinking. It became clear that it is a difference to possess the knowledge of project methods and to be able to actually apply them. Teachers do need confidence and the expertise in facilitating constructivist learning. There is a need for Design Thinking in teacher education, which could be analyzed in further research. §

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What Is Tinkering?

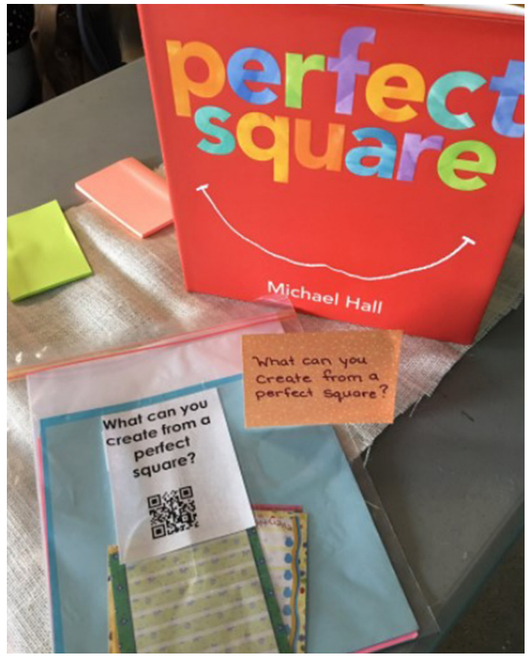
Nicole Lakusta

The *Canadian Oxford Dictionary* says that to tinker is to "attempt to repair or improve something in a casual or desultory (unfocused) way." The *Free Dictionary* says that a tinkerer is "one who enjoys experimenting with and repairing machine parts."

The Tinkerlab is a place where children are encouraged to follow their curiosities, test how materials work, experiment and ultimately combine materials and ideas together in new, inventive ways. Every Tinkerlab is unique, and the projects are diverse. Below are just a few samples of things to do in the lab:

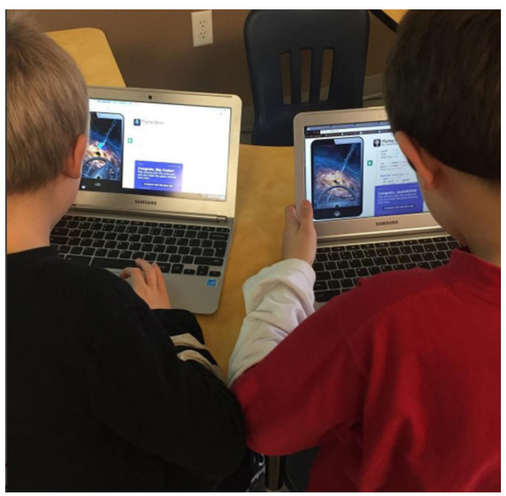
- Electronics: LED Hula Hoop, lit up knitted scarves
- Robot building, robotics
- Snap circuits where students create exciting projects, such as FM radios, digital voice recorders, AM radios, burglar alarms and doorbells
- Take-a-part sessions
- Coding
- Rube Goldberg machines
- Construction (wood, clothing)
- Maker and design challenges where students create something in response to a challenge question and/or connection to curricular outcomes

Several early years (K–4) schools in Parkland School Division No 70 are creating or have Tinkerlabs. Students use donated recycled materials, inexpensive supplies, which can be found anywhere, as well as high-tech resources while they design, create and show their prototypes.



Learning through play. Literacy challenges at our kindergarten PD day.

Please take time to watch a three-minute video that highlights Parkland Village School's Tinkerlab showcase to Parkland's board of trustees at https://youtu.be/PpMaAlDleaI. Find more exemplars below. §

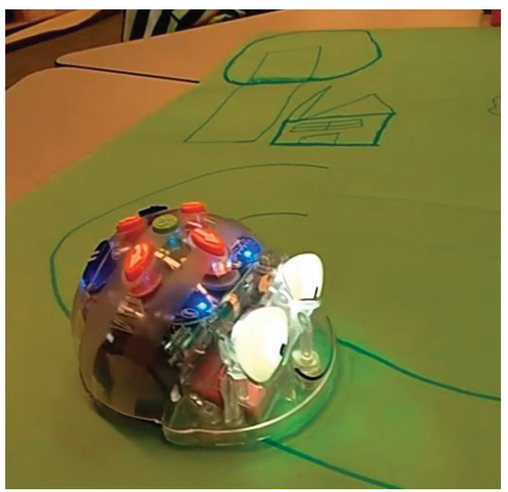


We are getting good at creating Bitsbox to create our own apps!

We love using real tools!

Programming music in coding club this week!

Building code for Milo!



Joey got Blue-Bot to follow his map. When he turned the wrong way, Joey moved him back and recoded Blue-Bot to go the right way.

ETC
LEARN.
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CREATE.

ETCATA would love to publish various articles by its members.

If you attend a wonderful technology conference, have a great review of an application (software, Web 2.0, tablet and so forth) or would like to recommend an article, contact **John Korassa** (john.korassa@ecsd.net).

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Complete contact information for the ETC executive is available on the council's website at https://etc.teachers.ab.ca/pages/home.aspx.

THE EDUCATIONAL TECHNOLOGY COUNCIL NEWSLETTER

Bits & Bytes

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Edna Dach Educator of the Year Award

Award Criteria

Overview

The ETC Edna Dach Educator of the Year Award is presented to a classroom teacher and/or technology leader in an educational setting who works to promote technology in education through:

- leadership in educational technology,
- best practices relating to technology integration, and
- professional development for teachers for integrating technology into the curriculum.

Eligibility Requirements

- The nominee is a current member of Educational Technology Council of the ATA.
- The application must include 2 letters of support (maximum two pages each) stating that the nominee is a professional worthy of being considered as an outstanding educator.

Award Criteria for Consideration

- The nominee has demonstrated leadership in educational technology.
- The nominee is committed to best practices relating to technology integration.
- The nominee is committed to continuing professional development in technology education.
- The nominee has contributed to the profession by providing professional development opportunities for teachers regarding integrating technology into the curriculum.
- The nominee has contributed to the profession by presenting at professional conferences.
- The nominee has contributed to the profession by publishing articles in print and/or through electronic media.
- The nominee's work has had a significant impact on educational technology locally, provincially, nationally and/or internationally.

Submission

Please submit your completed application form to:

Gerald Logan
ETC Past President
31 Pinnacle Crossing
Grande Prairie, AB T8W 0A9
e-mail: glogan@me.com Subject Line: Edna Dach Educator of the Year Award

Deadline: midnight May 15, 2018

Selection

1. Nominations for the award will be judged by a selection committee composed of Table Officers of ETC.
2. The ETC Edna Dach Education of the Year Award 2017 will be announced at the Annual General Meeting in March. The award recipient agrees to have his/her name and biography published and to submit a photo suitable for publication in the ETC Newsletter *Bits and Bytes*, and on the ETC website.

Last Updated: January 16, 2018

ETC Educational Technology Council
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Edna Dach Educator of the Year Award
Award Application

Nominee's Data

First Name: _____ Last Name: _____

Years of Teaching: _____ Nominee's Job Position: _____

Location (Check as many as apply) Rural ☐ Suburban ☐ Inner City ☐ Urban ☐

Nominee's Jurisdiction: _____

Nominee's Work: Address:_____

City:_____ Postal Code: _____

Nominee's Phone: Work: _____ Home: _____

Nominee's e-mail address: _____

I am a current ETC member, acknowledge this nomination and agree to the conditions of the Award.

Nominee's Signature: _____ Date:_____

Nominator's Data

First Name: _____ Last Name: _____

Years of Teaching: _____ Nominee's Job Position: _____

Nominator's Jurisdiction: _____

Nominator's Work: Address:_____

City:_____ Postal Code: _____

Nominator's Phone: Work: _____ Home: _____

Nominator's e-mail address: _____

I am a current member of ETC and recommend this individual for the ETC Edna Dach Educator of the Year Award.

Nominee's Signature: _____ Date: _____

Include the following:

- ☐ Application form with signatures
- ☐ Two letters of Support (maximum two pages each)

ETC Educational Technology Council

LEARN. CONNECT. CREATE.

Teaching and Learning through
Innovative Technologies Grant
Award Criteria

Overview
The ETC Teaching and Learning through ***Innovative Technologies Grant*** is presented to a classroom teacher(s) and/or technology leader(s) in an educational setting who work(s) to promote technology in education through best practices relating to innovative technology integration. The action research focus for the Educational Technology Council for the upcoming year is personal-owned devices with an emphasis on how devices owned by students are used in the classroom; however, this grant can also support a project of your choice.

Eligibility Requirements
- The applicant(s) is/are a current member(s) of Educational Technology Council of the ATA. Pre-service student members are also eligible.
- The applicant submit(s) a *Project Proposal* outlining an innovative action research project which promotes technology integration in the area of personal-owned devices with an emphasis on how devices owned by students are used in the classroom or a project of your choice.

Award Criteria for Consideration
- The project demonstrates effective and engaging technology integration into the K-12 curriculum.
- The project is innovative and/or reflective of emerging technologies.
- The project is topical based on new curriculum being implemented in the Province of Alberta or new initiatives being undertaken with emerging technologies.
- The applicant commits to being prepared to share their action research based on the project, posting their project (or a link to their project) on the ETC website, and presenting at an upcoming annual conference, regional workshop, webinar and/or virtual presentation.
- Up to three separate grants of $1000 each will be offered to ETC members in support of action research projects involving technologies in education; successful applicant(s) will receive 50% of the grant upon startup and 50% upon completion of the project. The grant must be used to start or complete a project; grants cannot be received in retrospect, i.e. when a project is complete. The number of awards being presented will depend on the quality of the proposal(s) and the financial resources available for distribution.

Submission
Please submit your completed application form to:

Gerald Logan
ETC Past President
31 Pinnacle Crossing
Grande Prairie, AB T8W 0A9
e-mail: glogan@me.com Subject Line: Innovative Technologies Grant

Deadline midnight March 15, 2018

Selection
1. Nominations for the award will be judged by a selection committee composed of the ETC Executive.
2. The ETC Teaching and Learning through ***Innovative Technologies Grant*** shall be presented at the Annual General Meeting in the spring.
3. The award recipient agrees to have their name and biography published and to submit a photo suitable for publication in the ETC Newsletter *Bits and Bytes*, and on the ETCATA website.

Last Updated: January 16, 2018

ETC Educational Technology Council
LEARN. CONNECT. CREATE.

Teaching and Learning through Innovative Technologies Grant

Award Application

Applicant's Data

First Name: _____ Last Name: _____

Years of Teaching: _____ Nominee's Job Position: _____

Location (Check as many as apply) Rural ☐ Suburban ☐ Inner City ☐ Urban ☐

School Jurisdiction: _____

Work: Address:_____

City:_____ Postal Code: _____

Phone: Work: _____ Cell: _____ Home: _____

e-mail address: _____

I am a current ETC member and agree to the conditions of the Award.

Lead Teacher's Signature: _____ Date: _____

Project Proposal

Please include the following in your project proposal (application + 2 pages maximum):

1. **Award Application with signature**
2. **Project Name**
3. **Intended Grade Levels**
4. **Intended Subject Area(s)**
5. **Proposed Timeline**
6. **How technology is being integrated**
7. **How action research will be conducted and recorded**
8. **How you will document and comment on opportunities and challenges of your project**
9. **Proposed budget** (Grants may be used for hardware, software, telecommunications connect charges, teacher release time, or any other worthwhile component of the project. Hardware and software purchased with grant monies become the property of the school in which the teacher carried out the project. Projects may receive funding from other sources as long as the expenses outlined in the proposal are paid for by the ETCATA grant. No project should make a profit by acquiring funding from many sources.)
10. **School Support** (Projects with school support are preferred. This support could take the form of matching funding, teacher preparation time, etc.)
11. **Sharing the Results** (Completed projects must be shared with other educators in an appropriate format such as print, video, web sites and/or conference presentations.)
    - Description of Support Website and/or Paper
    - Outline the title and description for the session you'd be willing to give at an upcoming annual conference, regional workshop and/or virtual presentation.

Submission

Please submit your completed application form to:

Gerald Logan
ETC Past President
31 Pinnacle Crossing
Grande Prairie, AB T8W 0A9
e-mail: glogan@me.com Subject Line: Innovative Technologies Grant

Deadline midnight March 5, 2018

Selection

1. Nominations for the award will be judged by a selection committee composed of the ETC Executive.
2. The ETC Teaching and Learning through ***Innovative Technologies Grant*** shall be presented at the Spring PD Event & AGM.
3. The award recipient agrees to have their name and biography published and to submit a photo suitable for publication in the ETC Newsletter *Bits and Bytes*, and on the ETC website.

Last Updated: January 16, 2018