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Publisher: The Technology, Environmental, Mathematics and Science (TEMS) Education Research Centre, which is part of the Faculty of Education, The University of Waikato, publishes the journal.

Contact details: The Editor, AJTE, pjohn.williams@curtin.edu.au

Cover Design: Roger Joyce

ISSN: 2382-2007

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Design of an authentic innovation project in Swedish upper secondary technology education

Joachim Svärd
Konrad Schönborn
Jonas Hallström

Abstract

According to the Swedish curriculum, the subject of technology should develop entrepreneurial skills that support curiosity, confidence, creativity and courage, resulting in the ability to act, in innovation and problem solving – a vision closely related to authentic learning. *Reeves, Herrington and Oliver (2002) define authenticity through nine key elements, namely, authentic context, authentic task, presence of expert performances, multiple perspectives, collaboration, reflection, articulation, metacognitive support and authentic assessment. The aim of this study is to map these authentic learning elements onto the design of a five-week innovation project (IP) module in a Swedish upper secondary school. Firstly, related literature and Swedish technology education curricula were analysed. Secondly, each element of authentic learning was described in terms of implementation in the IP. Results show how the criteria of nine elements of authentic learning could be used as a valid theoretical tool to develop and produce an authentically cogent learning module.*

Keywords: authentic learning, Swedish upper secondary education, technology education, module, entrepreneurial skills, twenty-first century skills.

Introduction

Technology is interdisciplinary in nature (Skolverket, n.d.) which makes it a compelling domain to study from both a specific technology education and general educational standpoint. However, a World Economic Forum report (2016) states that "most existing education systems at all levels provide highly siloed training and continue a number of 20th century practices that are hindering progress on today's talent and labour market issues" (p. 32). Even as early as 1991, scholars such as Blumenfeld et al. reflected on one of the key issues, motivation, in education:

> If one of the important goals of schooling is to foster the development of students' minds by engaging them in sophisticated and substantial opportunities for deep understanding of curriculum content, then educators must concern themselves with motivational questions that examine how students engage in and persist at such activities. (1991, p. 369)

In 1987, Resnick was already proposing new ways of schooling that are a meaningful 30 year-old reaction to the World Economic Forum's concerns of today. Resnick defined them as:

> … preparing people to be adaptive to the various settings they may encounter over the course of their working lives. Efforts to play this enabling function are likely to result in new forms of schooling that are also our best hope of preparing the next generation to participate knowledgeably and effectively in the civic functions of a technologically complex democratic society. (p. 16)

Designing authentic scenarios as part of educational intervention is a key component of such new forms of schooling. This is a key challenge for any teacher, since risk-taking, questioning, creating and imagining, cannot flourish under stressful conditions (Ciolan & Ciolan, 2014). In response, Beghetto and Kaufman (2014) add that, "teachers should view themselves and their teaching as a creative act. They will then be in a better position to model, encourage, and support their students' novel ideas, sensible risk-taking, curiosity, and meaningful self-expression" (p. 65). Such innovative skills – often labelled "twenty-first century skills" – originated as a topic of discussion almost 35 years ago (The 21st century learning initiative, n.d.). The idea was that current curriculum needed updating, which meant that apart from traditional school subjects, pupils should also be equipped with extended knowledge through skills such as collaboration, creativity and entrepreneurship (NEA, 2012; Council of the European Community, 2008), or as the Council of the European Union states, "schools need to foster creativity and a spirit of innovation and enterprise in their pupils" (2008, p. 21).

In terms of the connection between twenty-first century skills and ideas of authentic learning, Rotherham and Willingham (2010) lucidly suggest that "advocates of 21st-century skills favour student-centered methods – for example, problem-based learning and project-based learning – that allow students to collaborate, work on authentic problems and engage with the community" (p. 19). Resnick (1987) states that "school should focus its efforts on preparing people to be good adaptive learners, so that they can perform effectively when situations are unpredictable and task demands change" (p. 18). We also find such aspects of direct relevance to the idea of authentic learning in teaching. We therefore aim to explore how key elements of authentic learning can inform the design of an innovation project for implementation in a Swedish upper secondary school context.

Background to authentic learning practice

The mantra learning through experience is a universal conviction emanating throughout the development of human civilisation. For example, Aristotle's observation that, "for the things we have to learn before we can do them, we learn by doing them" (Aristotle, 350 BCE) as well as Xun Kuang's, "not having heard something is not as good as having heard it; having heard it is not as good as having seen it; having seen it is not as good as knowing it; knowing it is not as good as putting it into practice", (Xun Kuang, 250 BCE, in Knoblock, 1990) are both more than 2000 years old and emanate from different corners of the world. As noted by Dewey (1897, 1916), when schooling became institutionalised in the mid-1800s, it also became increasingly isolated from everyday life. Unfortunately, according to scholars in pedagogy as well as in psychology, this isolation often remains the case (Gardner, 1991; Newmann, Marks & Gamoran, 1996; Resnick, 1987; Roelofs & Terwel, 1999).

Authentic learning is described extensively in the literature, but with two major caveats; there is no universal, clear-cut and operationalised definition for what elements actually constitute authentic learning per se, and it is a concept not extensively researched (De Bruyckere & Kirschner, 2016). For example, the idea can comprise multiple aspects depending on whether considered by a student or a teacher, on whether problems need to be perceived as authentic by the pupils themselves or with regard to technological praxis, as well as on the meaning of the term in relation to technology education programmes (Turnbull, 2002). Eddy and Lawrence (2013) point to the Greek origin of "authentic" being "auto" and "-hentes", meaning "self doer", and state that "what lies at the foundation of 'authenticity' in learning is the notion that the individual is not only the learner, but also the doer" (p. 265).

According to Hennessy and Murphy (1999), successful authentic teaching activities that are associated with engaging and encouraging learning are those that are personally meaningful to the student, and also purposeful from a societal point of view. Such an approach often takes the form of encouraging pupils to solve problems seen as real-world dilemmas, where the pupils also become emotionally engaged in finding a solution to the problem. In a broad sense, most people concur with ideas such as authentic learning being about real-world problems; they are dealt with not only to promote the subject domain of technology but also to evoke twenty-first century skills such as creativity, critical thinking and problem solving capability (Brown, Collins & Duguid, 1989; Collins, Brown & Newman, 1988; Herrington, Reeves & Oliver, 2010; Nicholl, Flutter, Hosking & Clarkson, 2013; Reeves, Herrington & Oliver, 2002; Rule, 2006).

The importance of authentic learning tasks is further enhanced by studies on the Swedish labour market, which show that almost half (47%) of the Swedish work force is already subjected to working conditions requiring significant mental self-government (Allvin, Mellner, Movitz & Aronsson, 2013). In the “Future of jobs” report (World Economic Forum, 2016), the World Economic Forum concludes that schools need to offer a combination of mathematical skills, social skills, content skills (i.e., ICT), cognitive abilities (i.e., creativity) and process skills (i.e., critical thinking). There have been numerous attempts to find ways to introduce and integrate real-world issues into schooling. Such interventions could all be described as authentic educational practices that are also coupled to various potential benefits and limitations (Blumenfeld et al., 1991; Dilworth & Revans, 1998; Kolb, Kolb, Passarelli & Sharma, 2014; Lave & Wenger, 1991; Lombardi, 2007; Yew & Goh, 2016). Authentic Learning is the focus of this study since it can be investigated not only from the perspective of technology-as-subject, but also extended to general education at large, from pre-school to university. Pedagogical approaches related to promoting authentic educational practice have emerged at various points in the history of education. Table 1 presents the emergence of different authentic-related learning practices over time.

Table 1. Different authentic pedagogical practices and their salient emergence in the literature.

Pedagogic Practice	Project-based learning	Problem-based learning	Experiential leaning	Action learning	Situated learning	Authentic learning
Emerging	1910s	1960s	1970s	1980s	1990s	2000s

Table 1 was synthesised based on consulting the literature around authentic learning at large and observing approximately when each pedagogical practice emerged saliently. The pedagogical practices identified in the table are still used and applied extensively and have all been hailed as well as criticised over time. The following sections present examples of literature sources used to describe each of the six pedagogical ideas presented in Table 1 and their relation to ideas of authentic educational practice.

Project-based Learning

With its roots in sixteenth century architectural education, Project-based Learning can be seen as a working pedagogical idea since 1918 when William Kilpatrick (a disciple of Dewey), published “The project method” (Knoll, 1997). The basis of a project-based learning activity is a central question that drives the subsequent activities in the project, resulting in a final product that aims to answer the question. In education, students are often given the responsibility for posing a question as well as generating approaches for how to solve it, and in which way to present the product. The product could be manifested in a diversity of ways that include a physical product, a presentation, or a website (Blumenfeld et al., 1991).

Problem-based Learning

Problem-based learning was developed by teachers at McMaster University in Canada during the late 1960s. Originally designed for medical education, the method has also impacted other disciplines over the years, at first mainly at the tertiary education level, but also later in K-12 education. The basic idea of Problem-based Learning is similar to Project-based Learning in that they are both student-centered with a problem driving them. The main differences are that Problem-based Learning usually includes a task designed by the teacher and is more limited in time, whereas Project-based Learning emphasises open-ended questions, usually in the form of a major project (de Graaff & Kolmos, 2007). De Graaff and Kolmos describe the difference as "based on varying degrees of self-direction by the students" (p. 5). Problem-based and Project-based Learning are both referred to as PBL (Larmer, 2014).

Experiential Learning

During the early 1970s, Fry and Kolb developed the Experiential Learning Model (ELM). The underpinning idea driving the model is that knowledge is created through experience via a cyclical and spiral-like development. Such a cycle typically starts with a Concrete experience, followed by Reflective observation, then to an Abstract conceptualization, finally resulting in Active experimentation, which feeds back to a new cycle that commences again with a new Concrete experience (Fry & Kolb, 1979; LeBlanc, Léger, Lang, & Lirette-Pitre, 2015). In 1984, Kolb presented Experiential Learning Theory (ELT) grounded in six assumptions: learning is a process, not an outcome; it is derived from experience; it requires problem solving; it is holistic and integrative; the learner shares an interplay with the environment; and it results in knowledge creation (Kolb et al., 2014; Smith, Butcher, Litvin, & Frash, 2015; Wingfield & Black, 2005).

Action Learning

Inspired by ELM, the perspective of Action Learning (AL) was developed by Revans in 1982. Here, learning is also seen to evolve in a spiral-like fashion that takes the form of reflecting on a problem, planning a solution, taking action, and then proceeding back to reflecting upon the outcome. The underlying basis for AL comprises a real problem, work in a group, a process of curiosity, inquiry and reflection, conversion of talk into action, and a commitment to learning. Action learning is often used in adult education in an authentic environment such as corporate management (Dilworth & Revans, 1998).

Situated Learning

Gardner (1987, p. 256) describes situated learning as an "attempt to infuse careful case studies with concepts of cognitive science, while contrasting learning in the field with thought processes taught and measured in Western schools". Evolving from work by Brown et al. (1989), situated learning was presented as a method that was especially well-suited to adult learning as advocated by Lave and Wenger (1991). The idea was to bring learning into the environment where it is supposed to be used and applied. Examples could include learning about biology in a greenhouse or garden, or teaching handicraft in a workshop. According to Stein (1998), situated learning integrates content (application-based problems), context (in the real social and material environment), community of practice (provides the opportunity for interaction), and participation (sharing and interacting with other learners).

Authentic Learning

Rule (2006) analysed 45 articles describing authentic learning. Four themes supporting authentic learning emerged: real-world problems treated in a professional way with findings presented to an audience beyond the classroom; open-ended inquiries that promote thinking skills and metacognition; discourse among a community of learners; and empowering students through a choice of relevant projects.

In 2000, Herrington and Oliver offered their first definition of authentic learning based on situated learning. The authors identified nine key elements that are subsumed within a situated learning perspective, as described by Brown et al. (1989). In 2002, Reeves et al. went on to characterise authentic activities as having real-world relevance, being imprecise, complex, and requiring a longer time to solve, which in turn, provided opportunities for students to examine tasks from different perspectives. This could provide collaborative and reflective opportunities by integrating different subject areas (including integrated assessment), which resulted in an end product rather than a series of prepared steps, and, finally, being open to different answers or solutions. In 2010, Herrington et al. defined nine key elements of authenticity as comprising Authentic context, Authentic task, Presence of expert performances, Multiple perspectives, Collaboration, Reflection, Articulation, Metacognitive support and Authentic assessment, which placed Authentic learning at the junction between authentic task and academic setting as illustrated in Figure 1. This nine-tier definition of authenticity is used as the theoretical framework for this study, where each element is unpacked and mapped onto development of the module.

Figure 1. Dividing tasks into authentic or decontextualized, and settings into academic or real through four quadrants representing different ways of learning. The lower right quadrant being learning at a real setting (practicum), is often viewed as the best way to learn, but unfortunately it is very time consuming. The upper right quadrant represents typical school tasks solved within a real setting (i.e., field trips). The upper left quadrant is probably what most learning is focused on; solving problems in school environments often not directly linked to reality. Authentic learning, represented in the lower left quadrant, happens in classrooms, as authentic tasks in an academic setting (Figure 1 was based on Herrington, n.d.).

The influence of "authenticity" has been studied both in and out of the classroom. Newmann, Bryk and Nagoka (2001) conducted a study of mathematical and writing skills in Chicago schools involving almost 5000 students in grades 3, 6 and 8. The work found a significant difference in performance between students exposed to complex tasks with real world relevance (authentic classroom tasks), such as writing a text convincing the reader about the importance of something, or composing graphs about the stock market, and students who were taught in a traditional manner (i.e., doing grammar exercises or adding fractions). Analysis showed that the students always seemed to benefit from being taught authentically in school, irrespective of grade level.

An Authentic learning approach has been advocated as a way to promote learner motivation (Fox-Turnbull, 2012) and critical thinking (Vu & Dall'Alba, 2014). Newmann and Wehlage (1993) state, "Knowledge is thin or superficial when it does not deal with significant concepts of a topic or discipline…" (p. 9). However, introducing authentic learning is demanding for both teachers and students. From a teacher's point of view, it is often a completely new way of thinking, which allows students to take responsibility for their own learning, by primarily providing scaffolding as support. The main problem for students identified by Blumenfeld, Marx, Soloway and Krajcik (1996) is the potential of social loafing in group activities. Some students are found to simply not contribute fairly to a group task, and hence, students who end up doing most of the work may feel exploited. Individual students can also dominate a group, forcing other group members to align with dominant views and solutions. There is also the risk of a group failing to solve the task due to the nature of the task, or the composition of group members. Blumenfeld et al. (1996) suggest that members be picked so that groups consist of high and middle, middle and low or only middle achievers. In regard to these circumstances, Newmann et al. (2001) expresses the importance of the teaching influence as "the intellectual demands embedded in classroom tasks, not the mere occurrence of a particular teaching strategy or technique, that influence the degree of student engagement and learning" (p. 31).

Creating the basis for authentic learning in technology education within an innovation project

A typical approach in technology education is to focus on the process of design and development, in addition to the acquisition and application of knowledge. Solving real-world problems enhances process abilities (Fox-Turnbull, 2012). However, assessment of students' ability to design and propose solutions goes far beyond the mere summative assessment of their knowledge and skills. The development of innovative teaching activities to meet the demands of ever more complex daily life situations for students, which often involves new materials, technologies and systems, can be very demanding for educators and curriculum developers (Fox-Turnbull, 2006, 2015; Kimbell, 1997; Snape & Fox-Turnbull, 2013). In this regard, de Vries, Hacker and Burghardt (2010) assert that:

> Teaching about technology and engineering is a challenge, given the impressive speed of technological development. If the goal is to educate for the future instead of the present or past, rapid changes in the technological domain make this work challenging. (p. 15)

Given the sentiments above, Resnick (1987) points out the necessity in using the appropriate tools when solving tasks in school. She argues against a predominant view that "pure thought" activities are better than using tools such as computers or calculators arguing, "In contrast, most mental activities outside school are engaged intimately with tools, and the resultant cognitive activity is shaped by, and dependent upon, the kinds of tools available" (p. 13). Furthermore, Fox-Turnbull (2012) states, "Understanding how students use tools and the expertise of others to construct knowledge and understanding about technology is a critical component to understanding the nature of technology education" (p. 55). In support of this view, Brown et al. (1989) have suggested that "…students need much more than abstract concepts and self-contained examples. They need to be exposed to the use of a domain's conceptual tools in authentic activities – to teachers acting as practitioners and using these tools in wrestling with problems of the world" (p. 34).

Study objective and aims

The aim of this paper is to map key elements of an authentic learning framework onto the development of a five-week innovation project for implementation in a Swedish upper secondary school context.

Methodological approach and context of study

The procedure for conducting the study was first, an extensive literature review was conducted of general and technology-specific educational literature on authentic learning, underpinning the field from both a historical and current point of view. Secondly, a hermeneutic method (Robson, 2011) of text analysis based on repeated reading and reflection upon the texts was deployed to selected texts. During this process, single text sections were related to the whole body of texts, the emerging pedagogical practices and the educational context in a reciprocal, re-interpretive way, thus gaining an increased understanding of the material from each reading (the hermeneutic spiral). Thirdly, the core authentic learning elements that emerged from the literature review were mapped onto the design of an innovation project in technology education.

Context of the course design

It was within the theoretical context painted above that the reseachers set out to plant the seed for a new teaching approach in Swedish technology education aimed at identifying, assessing, and promoting authentic learning. It is obligatory for all students in the upper secondary Technology program in Sweden to participate in the Teknik 1 (Technology 1) course, which makes it an ecologically valid course to study any potential intervention. Since the research team was interested in studying the effects of an authentic learning activity, a major product or service development project was intended for the course, so that students could be induced to work authentically, in line with Beghetto and Kaufman's (2014) assertion that "having students identify a need and work collaboratively with each other and outside experts to develop a creative solution for that need will help them creatively and meaningfully use what they have learned in the classroom" (p. 65). During the main part of the project, the students can make use of knowledge and skills obtained during other parts of Teknik 1 such as problem solving capabilities, design knowledge, knowledge of materials and material processing, and basics in drawing, modelling and CAD techniques. At the end of the project they will also be able to implement this knowledge in other mandatory applications such as construction, documentation, presentation and entrepreneurship.

Given the above, an innovation project (IP), where students plan their own work, adapt their acquired skills and knowledge and test their abilities in an authentic real-life project, was framed as the basis for creating tasks that could potentially result in the desired effect of nurturing keen and eager students with both technology-specific and generic, twenty-first century skills (Malone & Lepper, 1987; Nicholl et al., 2013; Watagodakunbura, 2013). The IP is envisioned to last the entire first year at upper secondary school, but in the form of various smaller components and one major component comprising 5 weeks (see Table 2). The students will aim to spend 26-40 hours of the total allocated teaching time on the project (corresponding to as much as a third of the allotted course time). The available time spent on the innovation project also depends on the possibility of cooperating with other STEM and language subjects such as Swedish and English.

Structure and intended implementation of the course module

As stated previously, according to Herrington et al. (2010), the key elements of authenticity are Authentic context, Authentic task, Presence of expert performances, Multiple perspectives, Collaboration, Reflection, Articulation, Metacognitive support, and Authentic assessment.

Table 2. Proposed five stages of implementing the desgined IP module in a typical course year together with course content.

Stage	Month	Content
1	August	The course Technology 1 starts with problem solving techniques, such as "Six thinking hats" (de Bono, 1987), resulting in creative thinking skills. The students are asked to identify problems (defined as products or services that could work better) in their everyday lives. Lists of about ten items per student are sought.
2	January	The students form groups of three to four. Larger groups risk individuals loafing instead of contributing (Blumenfeld et al., 1996). Smaller groups narrow the angles of approaching a problem. The groups work independently on their tasks for about five weeks with nothing but scaffolding support offered by the teacher, in line with Barak and Zadok's (2009) assertion that instructions should be given in the context of students' work on their projects.
3	February	At the end of the main project period, the results are exhibited over a full day at school. Models, drawings and statistical data are expected, but ideally even functional prototypes, webpages and computer programs could be displayed. At the exhibition, each project will be assessed by students from the other groups on how well the innovation solves the problem, and how convincing the accompanying presentation of the solution is. There will also be external experts present to assess the results.
4	March	The students describe the project formally in the form of an extensive technical report. This process is predicted to take at least two weeks, which offers a period to reflect upon, modify and formulate students' thoughts on the project.
5	June	By the end of the school year, the students complete the project by naming both the product/service and imaginary company that should provide it, together with an accompanying logo to represent their product. As the groups present their results, they also have the possibility to demonstrate any improvements or

	alterations in their original innovation that they might have integrated during the previous months of reflection and modifications.

The students will be encouraged to work in line with Schön's (1987) ideas about reflection-in-action and reflection-on-action, the former taking place during steps two and three as the students are encouraged to "think on their feet". The latter will take place during steps four and five as the students have had the opportunity to reflect on the process through, for instance, the technical report and a second reengagement with the original problem, if required.

Producing an intervention for promoting authentic learning: Mapping elements of authenticity onto the design of an IP module

Elements of authenticity in the IP module design were identified through the definitions provided by Herrington, as described earlier. Table 3 presents how the characteristics of each element was unpacked and mapped to examples of respective proposed implementations in the foreseen IP module (Table 2).

Through the mapping process represented in Table 3, the research team found a valid coherence between the criteria of Authentic learning as defined by Herrington et al. and the design of the IP module. As mentioned earlier, there should also be multiple opportunities to foster creativity, critical thinking, cooperation and ICT as called for in the "Future of jobs" report by World Economic Forum (2016).

Implications and future research

Herrington et al.'s (2010) framework provides a theoretically-based definition of authentic learning that can be applied to inform the design of interventions that result in engaging, complex, and real-life tasks for students to act upon and find solutions to. The results of this study indicate how the criteria within the nine elements of authentic learning can be adopted in a cogent way to the design of an IP module. Exploring implementation of the authentic learning module in a subsequent study will aim to represent Turnbull's (2002) assertion that:

> Authentic learning in technology education means that students need to be involved in practices which reflect understanding of the culture of real technological practice. Skills and knowledge are far less relevant and meaningful if taught in isolation. Students need to, and have a right to, understand the relevance and place of their learning. (p. 39)

Problems from students' every-day life must be at the heart of such practices. Questions such as: How to wake up in the morning in an effective way? How to hold an umbrella and ride a bike at the same time? How can I make sure that all the information in my mobile phone is saved if lost or stolen? or How can I view my mobile phone in bed without getting a stiff neck? can lead to a multitude of possible workable solutions. With regard to how to prepare the students, the researchers hope to show that "this type of instruction should take place in the context of pupils' work on their projects, and adopt a qualitative approach rather than try to communicate in the class procedural knowledge learned by rote" (Barak & Zadok, 2009, p. 289).

The demonstrated mapping of the nine elements of authenticity to design of the IP module (Table 3) and the results of forthcoming studies will inform the subsequent investigation of implementation of the module. Ciolan and Ciolan (2014) have exposed discrepancies between the teacher's point of view and the student's in terms of how authentic a task is perceived. In future work, it could be interesting to compare the view of the student groups with one of the teachers, by posing questions such as: Does the engagement during the IP module affect the outcome of the project? And, Do the students experience a greater degree of satisfaction with the outcome? Other interesting aspects to measure might include how the entire course is perceived by posing questions such as: Is there a correlation between perceived authenticity and grades in Technology? Has the course changed the students' ideas about the future? and, Do students see themselves as future engineers or designers? We hope to respond to such questions to some extent after conducting interviews with students. We also hope to show evidence of reflection-in-action using questionnaires to record students' activities while they participate in the IP module.

Unfolding future studies in this research project will pursue the question: Can the authentic IP module designed promote a deeper understanding and engagement in technology education, resulting in genuine interest and skills for addressing real-world problems?

Table 3. Mapping of nine elements of authentic learning onto the design and proposed implementation of an innovation project (IP) module.

Element of authentic learning	Characteristics of the element (based on Herrington, n.d.; Herrington et al., 2010)	Example of proposed implementation of element in the (IP) module
Authentic context	• Provides the purpose and motivation for learning • A design to preserve the complexity of a real life setting • Ideas can be explored at length in the context of real situations	The purpose of the project is finding a solution to a real-world problem. The task is constructed by the students themselves and has no pre-determined sequence of solution. Only a few activities are mandatory, for example, presentation at an exhibition at the end of the IP module.
Authentic task	• Clear goals and real-world relevance • Requires production of knowledge rather than reproduction. • Complex and imprecise • Completed over a longer period • Task can be integrated across subject areas	The task, resulting in models, prototypes, drawings and/or programs, is presented at an exhibition at the end of the main project, stage 3 in the module (Table 2). At this exhibition, students present their solutions in a business-like manner, trying to interest the visitors in their solution with any appropriate tools such as digital presentations, information leaflets, business cards and verbal communication.
Expert performances	• Access to experts, or to the way an expert would think and act, through personal contacts or websites. • Access to learners at various levels of expertise since students often learn better from someone only slightly better then they	Extensive search for information on the internet; companies, universities, interest groups, TED talks and official pages of authorities and ministries. The students can contact experts at companies and universities. There is also the possibility to consult senior students and teachers in various subjects.
Multiple perspectives	• Not just a single perspective - such as a textbook • Different perspectives on topics from various points of view • Varied forms of media accessible on internet resources	The task should be solved using the best possible sources of information, regardless of whether this is through text resources, companies, organisations, the internet, or other sources.
Collaboration	• Teams or pairs rather than individuals • Collaboration encouraged through information and communication technologies • Task addressed to groups, not individuals • Appropriate incentive structure for whole group achievement	The task is solved in groups of 3 or 4 students. Documentation is shared within the group, with the teacher, and through sharing applications such as Google Drive. The performance of the group, rather than the individual, is seen as most noteworthy.
Reflection	• Opportunities to make choices • Students are able to return to any part of the project if desired	Since all work is done within the group and over a significant period of time, there are multiple opportunities for discussion and reflection during the process. At the

	• Opportunities to compare their output with other students and experts	exhibition, the students evaluate the other groups' work and the results from this are compiled by the teacher and provided to the group members. External professionals should be present at the exhibition asking questions and giving feedback to the groups. After the exhibition, the students compile individual reports on the project and reflect on what they have achieved and what they would have altered. At the end of the school year, the students have the possibility to revaluate and suggest improvements to their innovations.
Articulation	• Public presentation of argument to enable defence of position and ideas	The students prepare a professional presentation of their project at the exhibition. They present it roughly as many times as there are students present. This is especially demanding if there is an external professional present. Besides the oral presentation, students have to produce digital presentations (e.g., Power Point slides, leaflets and a technical report). At the end of the school year, the project is presented again, naming and explaining the names and logos chosen for the product or service. Emphasis is placed on the finished product or service being as professionally presented as possible.
Metacognitive support	• Teacher's role is support at a metacognitive level rather than teaching, where emphasis is on, for example, answering a student question with a follow up question to scaffold the student's reasoning, rather than simply transmit knowledge. • Collaboration where more able partners can assist	No traditional teaching should take place during the IP module. The teacher's role is that of a senior colleague who can give good advice.
Authentic assessment	• Seamless integration of assessment and task • Opportunities to craft finished products or performances rather then exercises or sub-steps in preparation of something else • Significant student time and effort in collaboration with others	The innovation process is assessed by the teacher as s/he observed the groups' activities. The finished product/service is assessed primarily by other students, but preferably also by an external professional. If the project is successful, it is also possible to enter innovation competitions where students and their innovations are scrutinised by a jury.

Affiliations

Joachim Svärd
Doctoral student
Linköping University
joachim.svard@liu.se

Konrad Schönborn
Associate Professor (docent)
Linköping University
konrad.schonborn@liu.se

Jonas Hallström
Associate Professor
Linköping University
jonas.hallstrom@liu.se

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