Applying Eye-Tracking Technology in the Field of Entrepreneurship Education

Lina Kaminskiene, Kateryna Horlenko, and Ling Yi Chu

Abstract Eye-tracking application in social sciences including entrepreneurship education has increased significantly in the recent years. This technology has been used to investigate the learning process and how to foster it through instructions delivered, material used and the learning environment created. Traditional research with eye-tracking application mainly concentrates on visual aspects in the learning process including but not limited to text comprehension. A growing area of eye-tracking technologies is focused on entrepreneurship education including teacher education because schools are considered as an important stage for developing entrepreneurial competences.

In general, the area of the application of eye tracking has become extremely wide in different sciences which also positively contributes to research in education. Transdisciplinary and multidisciplinary approaches are helpful to ensure multiple perspective as well as to ensure the validity of research data and results.

This chapter is an attempt to critically reflect on how eye-tracking methodology is applied for research on entrepreneurship education and what are growing methodological challenges in it. At the end some implications for further studies in the field of entrepreneurship education are discussed as well as limitations of eye-tracking-based studies are highlighted.

Keywords Eye tracking · Entrepreneurship · Entrepreneurship education

1 Methodology

The search and selection of the relevant literature was conducted among peer-reviewed journals in the field of education and social sciences. The search of literature was done through ERIC (EBSCO) database and was not limited to journals indexed in Web of Science or Scopus since entrepreneurship education study using

L. Kaminskiene (✉) · K. Horlenko · L. Y. Chu
Vytautas Magnus University, Kaunas, Lithuania
e-mail: lina.kaminskiene@vdu.lt

R. Adams et al. (eds.), *Artificiality and Sustainability in Entrepreneurship*, FGF Studies in Small Business and Entrepreneurship,
https://doi.org/10.1007/978-3-031-11371-0_8

Table 1 The inclusion and exclusion criteria for literature review

Criteria	Inclusion criteria	Exclusion criteria
Sources of information	Include articles based on empirical findings or theoretical analysis. Articles published in the peer-reviewed, open access journals, full-text articles	Exclude sources published without peer review, with no full text available
Content	Include studies where eye tracking is regarded as a core subject. Include papers related to K12 education, higher education in general, learning concepts in isolation	Exclude studies where eye tracking is not a core subject, studies related to specialised higher education (medicine, geology, etc.), studies not in the field of education (e.g. in neuroscience)
Type of study	English, quantitative and qualitative studies, reviews, full conference papers	Conference abstracts, reports and editorials, commentaries
Availability	Full text accessible to the authors	Full text non-accessible to the authors

eye-tracking methodology is a relatively new area of investigation. The process consisted of several steps. The search was done using the keywords 'eye tracking' and 'education'. This produced a vast number of sources. Seeking to narrow down the search, we included the keywords such as 'entrepreneurship' and 'education'; however, these keywords did not help in identifying the most relevant publications. After screening the available abstracts of articles generated from the initial search, we came up with 505 papers relevant for further analysis.

The second step involved a careful analysis of the abstracts and applying inclusion/exclusion criteria (Table 1) to select the most relevant publications. Papers which did not directly deal with eye tracking in the field of education and in entrepreneurship education were excluded from further analysis. Some EU-level policy documents were included in the study to present the political context of entrepreneurship education in Europe. To ensure the saturation of the data, additional papers specifically focusing only to entrepreneurship education were added. The final sample of the analysed data sources consisted of 105 articles, studies, conference papers and EU policy documents.

2 Entrepreneurship Education

In its fundamental sense, the term entrepreneurship refers to starting and developing new ventures, connecting resources with opportunities and creating value (Gartner, 1990). Within a more holistic approach, it can reflect a worldview that accepts change as a natural part of life (Johannisson, 2018), implying an active, creative, self-reliant individual. Both types of definitions have implications when adapting the term to the context of education, that is, equipping students with knowledge about and skills for entrepreneurial activity.

One of the debates in the field of entrepreneurship education is related to the twofold view on entrepreneurship: should its focus lie on the process of business creation or on the development of entrepreneurial individual? The current view on entrepreneurship education seems to aim combine both approaches, with the latter being relevant for all levels of education, and the former more suitable for the secondary and higher education levels (Lackeus, 2015). While entrepreneurship education is grounded in the entrepreneurial activity as such, approaching it from education science perspective shifts the focus to the learner as a human being and her skills, beliefs and intentions (Kyrö, 2018). A major goal of entrepreneurship education is to help students embrace the entrepreneurial worldview and self-reliant attitudes (Gibb, 1993). Entrepreneurship education implies the development of attitudes, behaviour and capacities on the individual level because entrepreneurship may be manifested through skills and attitudes which are revealed and implemented through personal career. This in a long-term perspective creates value to the society and economy. Entrepreneurship education can contribute to the enhancement of entrepreneurial and innovation culture, by changing mindset and equipping individuals with relevant skills.

Entrepreneurship education shares similarities with the principles of progressive education and constructivist learning paradigms. It promotes collaboration, cooperation and search of new perspectives. It prepares students to recognise opportunities and take action in the environment characterised by complexity, thus emphasising creativity and personal agency and ability to face risks and assume responsibility (Kyrö, 2018). The classroom activity is learner-centred and even learner-led when learners are supported to follow own interests and find ways to apply them in reality. The goal of the process is value creation, that is, bringing change to the environment by interacting with it and producing utilities for other people as stakeholders (Lackeus, 2015). Another distinctive characteristic of entrepreneurship learning is decision-making. In this regard, students can be made acquainted with different models of reasoning that are applicable for entrepreneurship. An example of such models is the effectuation process proposed by Sarasvathy (2001). According to effectuation thinking, the entrepreneur makes decisions exploring different outcomes based on the means she already has at hand, as opposed to causation thinking where it is needed to reach a certain predefined outcome and find means to do so.

The above-mentioned attributes of entrepreneurship education imply a greater focus on collaborative learning and personal initiative of students in the classroom. At the same time, student individual differences in terms of gender, cultural and social background as well as student personality and intentionality have influence on student involvement with entrepreneurship-oriented activities (Pittaway & Cope, 2007). Generally, the quality of entrepreneurship education largely depends on the concrete schools and resource availability. Also, teacher professional background has been identified as an important factor influencing implementation of entrepreneurship education (Ruskovaara & Pihkala, 2015). There is a noticeable variability in institutional implementation of entrepreneurship education and the underlying pedagogies, reflected in the case study reports as prevailing research evidence in the field (Pittaway & Cope, 2007). Reviews reported use of action learning, venture

creation simulation, venture development, role plays, experiential learning, project work, enterprise visits and mentoring as teaching methods (Solomon, 2007; Pittaway & Cope, 2007). Nowadays, the digital environment has become the new space for both learning and entrepreneurial activity, where the learning methods can be utilised and developed.

Entrepreneurship education can become a trigger to societal changes and a very important factor in the development of all sectors. The role of public and private sectors is equally significant while creating and developing efficient ecosystems which stimulate and support the creation of innovative enterprises. Even though contexts from countries may differ, entrepreneurship education in its various forms may provide possibilities to actively engage in their exploitation taking into consideration the existing environments and cultures.

Developing the entrepreneurship competence in learners is one of the core aims of entrepreneurship education (Komarkova et al., 2015; Tittel & Terzidis, 2020). Lackeus (2015) described it as a combination of skills, knowledge and attitudes that facilitate the entrepreneurial value creation. Students need to '*learn to see entrepreneurship as a journey rather than a destination [. . .] this must happen while the students themselves are in personal flux in both cognition and emotion*' (Welsh et al., 2016, p. 127). Lans et al. (2018) discussed entrepreneurship education and entrepreneurship competence in terms of 'what' and 'how'. The 'what' stands for the types of competences that build the entrepreneurship competence. The authors distinguished between the cognitive, social and moral competences. The 'how' elaborates the way students learn, namely, the pedagogies applied, types of assignments, learning goals and outcomes. The specifics of entrepreneurship education signify that the interplay between the cognitive and emotional aspects of learning is crucial for understanding it on the individual and group levels. This line of research has developed significantly in educational sciences in the past decades in the field of student engagement and self-regulated learning (Christenson et al., 2012) and is expected to develop in the context of entrepreneurship education as well (Kyrö, 2018). Moreover, expertise development (Ericsson et al., 2006) is present in entrepreneurship just like in other fields, allowing studying entrepreneurial competence in expert/novice paradigm, especially from the perspective of entrepreneurial cognition drawing on findings from cognitive psychology (Dew et al., 2009; Mitchell et al., 2004). The cognitive processes and heuristics typical for entrepreneurial perception and decision-making can be identified through expertise research and developed into teaching techniques for entrepreneurship education.

In Europe, relevance of entrepreneurship education has been linked to supporting the economies and employment on the one hand and promoting active citizenship and democratic values on the other (Kyrö, 2018). Entrepreneurship education in a higher education sector is traditionally focused on the development of entrepreneurial skills and mindset and to the support and recognition of entrepreneurial initiatives. Entrepreneurship education is a process which aims to develop individual mindset, behaviour and capacities which are employed in creating value in different contexts and environments. Active graduates should be prepared to use and exploit their potential and create their future as indicated by the European Entrepreneurship

Competence framework (EntreComp; Bacigalupo et al., 2016) and related studies (McCallum et al., 2018; McCallum et al., 2020).

In general, entrepreneurship is not only focused on the creation and development of one's own business. It is very much linked to creativity, innovation and growth, a way of thinking and acting which is significant for different contexts, environments and ecosystems. In this context the entrepreneurial ecosystem could be characterised as an interdependent and interactive system of entrepreneurial activity. This interdependence involves institutional regulations, environmental conditions which predetermine socially and economically perspective opportunities and how entrepreneurial individuals form and develop these institutional and environmental conditions.

3 Eye-Tracking Technology

Attempts to design eye-tracking equipment began as early as the nineteenth century and developed from various obtrusive methods with physical eye attachments to the contactless, non-obtrusive and often portable eye trackers used nowadays (Holmqvist et al., 2011; Wade & Tatler, 2005).

The core of the technology is recording the position of the eye and calculating its movement in relation to a screen or a scene. The eye tracker consists of an infrared light source pointed to the eye and a camera that records the pupil and the reflection from the light on the cornea (Holmqvist et al., 2011). Eye trackers can be remote, as a part of a computer, or mobile, designed as glasses. The former allows tracking-eye movements when looking at the computer screen, while the latter allows examining the gaze pointed to any object within the field of view. The mobile eye tracker has also a front-looking camera for first-person scene recording.

Elements of eye movement that present interest for eye-tracking research in education are fixations and saccades. Fixations are time intervals when the eye is comparatively still and acquires new information, that is, fixating on an object or a certain area. They can last from 150 ms to 600 ms and build the basis of visual perception (Duchowski, 2007). Saccades are quick movements from fixation to fixation when the eye does not acquire new information (Rayner, 2009). Understanding of how a person distributes attention can be gained from examining where, in what order and for how long fixations occur, with saccades as transitions in between. Fixations and saccades are analysed in relation to task-specific regions – areas of interest (AOI). The lengths of both measures depend on the task and complexity of the stimulus (Rayner, 2009). Measures of eye movement can be counted, or reported temporally and spatially (Lai et al., 2013). The count scale stands for the characteristics of fixations and saccades that can be counted (e.g. fixation number). The temporal category describes the time spent on a certain area (e.g. total fixation duration, average fixation duration, first fixation duration). The spatial category implies that fixations and saccades are analysed in the space dimension, that is, their locations and overall arrangement (e.g. scanpath pattern).

One more measure that the modern eye trackers can detect is the pupil size. Quick pupil dilation can indicate emotional arousal or mental effort (Martin, 2019). However, pupil size is sensitive to lightning conditions, so this measure needs to be treated with caution.

Educational research can make use of modern eye trackers in the laboratory or in the field. Laboratory settings make it possible to control conditions of the study. Holmqvist et al. (2011) mentioned several important points for laboratory settings. Controlling lighting is important for optimal eye tracker recording, and especially when measuring the pupil size. When using remote eye tracker, participants' head movement can cause noise in the eye-tracking data or lead to loss of calibration, so a chin rest is needed to stabilise the head of the participant. Eye trackers with multiple cameras and infrared sources are less sensitive to head movements. In addition, soundproof laboratories allow minimising external noises that could distract participants. Laboratory settings are suitable for examining separate elements of learning as a process and provide high internal validity but lack ecological validity (Duchowski, 2007). Studies in the field or 'on-site', on the other hand, need to respect the less controlled environment comparing to the laboratory. At the same time, the availability of state-of-the-art mobile and remote eye trackers allows such work and ensures ecologically valid authentic conditions for the research (Jarodzka et al., 2021). For the field of education, this is especially important, as learning and teaching are context-dependent, social and interactive processes that take place in connection with the environment (Jarodzka et al., 2017). Thus, eye tracking allows obtaining unique insights about human perception and cognition across several dimensions.

4 Theories Applied in Eye-Tracking Research

Eye-tracking technology allows focusing on instructional design issues and helps to explore how learning material is visually presented to eliminate distraction and optimise its function to support learning. Focusing on the flow of information processing to and within the working memory, the two most influential theories are the cognitive load theory (Chandler & Sweller, 1991) and the cognitive theory of multimedia learning (Mayer, 2009). Both theories work according to the assumption that working memory capacity is limited; learning only takes place where there is available capacity not consumed by inadequate instructional design; learning solely occurs where there is active engagement with the learning material.

Cognitive load theory (Chandler & Sweller, 1991) shines light on the scientific approach to the design of learning materials so that the pace and complexity are best comprehended by the learner. The goal is to make the best use of the limited working memory load by avoiding presenting tasks that are too difficult (monitor the 'intrinsic load'), improve the layout of the instructional material (reduce the 'extraneous load') and increase active engagement with the instructional materials (optimise the 'germane load'). Expanding on this, cognitive theory of multimedia learning

(Mayer, 2009) urges the importance to rethink multimedia instructional messages so that they guide effective cognitive processing during learning but not causing extra burden on the learner's cognitive system. The three assumptions on how humans process information are:

1. Channels for processing visual-pictorial and auditory-verbal information are independent of each other (the human mind is 'dual channel').
2. Most people can only maintain maybe five to seven "chunks" of information in working memory at a given time (human mind is 'limited capacity').
3. Learning happens when learners identify relevant information and work to synthesise words and pictures into meaningful information that is stored in long-term memory (human mind is an 'active-processing' system).

A related theoretical framework, cognitive-affective theory of learning with media (CATLM; Moreno & Mayer, 2007), also integrates the emotional aspects of multimedia learning with the cognitive ones. It postulates that both emotional and motivational factors have an impact on learning, that learners can regulate their emotions and motivation to support learning and that learners' individual differences influence the effect of multimedia instruction. Adopting a constructivist view of learning, multimedia is far beyond information delivery systems, but cognitive aids for knowledge construction. The theories offer similar guidelines on how to design instrumental material, focusing on its visual presentation—in order to optimise learning efficiency.

Jarodzka et al. (2017) proposed the second research line of eye-tracking research on visual expertise as the expertise developmental topics which explores learning beyond the initial stages. This is when the organisation of knowledge accumulates past the initial stages and into the long-term working memory (Ericsson & Kintsch, 1995). Information starts to scaffold into categorised chunks, or schema (van Lehn, 1996), which expands the working memory as more spaces are being made for other entities. These formed 'frameworks' that learners have created for themselves help to organise and interpret information, and these cognitive cues assists in learning new information by making connections to this prior knowledge. When a schema follows a temporal order, it is referred to as a script (Schank & Abelson, 2013). The schema is also organised and labelled with shortcuts where long chains of reasoning are folded away into one entity and only unfolds its chains when required (Boshuizen & Schmidt, 1992). The more efficiently organised their prior knowledge or schema a learner must work with, the more referencing material he/she has when trying to execute a task with speed and accuracy. A learner eventually proceeds into becoming an expert of their domain of expertise (Ericsson et al., 2006) where they can consistently and superiorly perform on specific sets of representative tasks from a domain (Ericsson & Lehmann, 1996). Experts demonstrate tacit knowledge when they encode domain-related patterns using their encapsulated knowledge as a reflection of chunking in perceptual processes (Reingold & Sheridan, 2011).

Difficulties to execute eye-tracking application to visually information-rich areas are where visual expertise is most relevant, as relevant information is difficult to be selected due to the presence of numerous irrelevant information, visual dynamic

environments lead to possibilities of visual saliency, and transient information and element of information may appear and disappear simultaneously—leading to split-attention effect. Jarodzka et al. (2017) also pointed out that stimuli used in visual expertise research are domain-specific and cannot claim to be representative, where findings cannot be generalised to other information-rich and dynamic domains.

The third line of eye tracking in educational research is the eye movement modelling examples (EMMEs), which bridges the novice learners to the experts. EMMEs are computer-based videos that display the gaze behaviour of a domain expert while they execute a problem-solving task. This is a training model, where (relative) novices learn from the experts using EMME as an instructional document (Xie et al., 2021). EMME video examples are professional vision (or the layover of the experts' visual focuses) simultaneously supplemented by the verbal explanations of the expert for complex real-life problems to be dissected and explained following the cognitive processes of the expert. The novice/learner is given the opportunity to look through the expert's eyes to guide the visualisation of the expert's cognitive processes by following how the experts' visual focus flows and hearing how the expert explains their own thought processes.

Some recent applications of eye tracking can help to follow the process of novices learning from experts. For novices, the idea builds on the principles of the social learning theory that learners observe and imitate authentic task completion from more skilled others (Bandura, 1977). For experts, eye movement illustrates the superior approach to tasks explained by the information reduction hypothesis (Haider & Frensch, 1999) and selective processing – engaging longer and more frequently with elements of task-relevant information (Crundall et al., 2012). Research on teaching and training applying this concept shows that learning by seeing an example of a task being successfully executed is more efficient than learning by trial and error (Kirschner et al., 2006). EMME provides an opportunity to show novices where to look and, more importantly, why (Kok et al., 2015), as there is no print trying to make novices act like experts. This is especially true when the critical processes are not observable from the outside and verbalisation of the experts' thoughts must be supplemented. Jarodzka et al. (2017) pointed out the importance of EMME models would be experts who are highly experienced in teaching their expert domain, to better associate their verbal explanation in accordance with difficulties that students typically face. EMMEs do not need to record the instinctive reaction of how experts solve tasks and can be repeated. It allows space for the experts to prepare and familiarise with the task, and to be reflectively aware of their audience (the novices) by thoroughly considering factors such as prior knowledge (Kalyuga, 2007), and evaluating whether gaze-voice coupling is tight enough during the recordings (Richardson & Dale, 2005).

5 Eye-Tracking Data and Analysis

As a scientific data collection method, eye tracking is credited for its objectivity, temporality, and for the field of education—the variety of study designs that can incorporate it. Eye movement is automatic; a person may not always be consciously aware of own gaze as it reflects both voluntary and involuntary attention (Duchowski, 2007). Besides, eye tracking provides an opportunity to observe and measure a cognitive process throughout a certain time period or in real time (Alemdag & Cagiltay, 2018; Kaakinen, 2021). To analyse the eye-tracking data beyond attention distribution or mental effort, and to make a clear connection between the eye movement measurements and cognitive processes, it is important to combine them with other sources of data (Lai et al., 2013; Orquin & Holmqvist, 2018). To name a few, these could be verbal reports (Jarodzka et al., 2013), cued retrospective reports (van Leeuwen et al., 2017), knowledge tests (Clinton et al., 2017) or video recordings (Pouta et al., 2021). Thus, data triangulation became essential in current eye-tracking research in education.

Eye tracking allows collecting rich and continuous data for each participant. It can be analysed quantitatively or qualitatively, depending on its type: count and temporal measures can be analysed quantitatively, while spatial measures require qualitative analysis. The choice of the analysis approach depends also on the research question and affects the study outcome (Kaakinen, 2021). Quantitative measures are analysed in relation to AOIs; the analysis may be based on several measures, such as number of fixations, fixation duration, number of repeated fixations and total fixation time (Holmqvist et al., 2011).

Qualitative analysis is based on examining gaze images and video recordings and is especially time-consuming. From data gathered from mobile eye trackers, researchers may need to review and code tens of hours of video recordings. Two common visual representations of eye movement for qualitative analysis are scanpaths and heatmaps (Drusch et al., 2014). Scanpaths show the sequence of fixations and saccades in the stimuli space or visual view. This helps researchers to follow participants' attention and cognitive processing, with a possibility to track memory patterns or arising difficulties (Duchowski, 2007). Scanpath analysis can lay ground for distinguishing groups of participants, such as experts and novices (Kaakinen, 2021), and developing EMME (Jarodzka et al., 2013). The other visualisation type, heatmaps, colour code areas are based on aggregated data from duration and/or number of fixations from one or several individuals (Drusch et al., 2014). Examples of heatmap usage in education studies include illustrating teacher's gaze over classroom (Coskun & Cagiltay, 2021) or identifying learners' approaches to tasks, such as when counting with the help of mathematical representations (Bolden et al., 2015). Presentation of the findings can be structured according to the research questions, themes or data sources, often including results of data triangulation.

6 Opportunities of Eye-Tracking Research in Entrepreneurship Education

Research on entrepreneurship education can be oriented in two main directions: the learning process and the assessment of its effects. Lackeus (2015) summarised the methods used to collect and analyse data about entrepreneurship education as thought-based, action-based and emotion-based, utilising such tools as experience sampling methods with mobile phone surveys, surveys based on theory of planned behaviour (Ajzen, 1991) and case studies, all of which reflect the traditional qualitative and quantitative methods. Drawing on eye-tracking studies in education, we focus on how eye tracking can be an additional objective method for enquiring into the learning process within entrepreneurship education.

It should be noted that the literature on entrepreneurship education heavily emphasises the learner and leaves out the teacher. As entrepreneurship education can take place on any educational level – from primary school to higher education – the teacher is the central figure in the educational process who enables the whole process (Ruskovaara & Pihkala, 2015). Therefore, we aim to add the teaching perspective by illustrating how eye-tracking research helps to define teacher expertise and to make connections to the domain of entrepreneurship education.

6.1 Research on Learning: Enhancing the Current Research Instruments

6.1.1 Components of Entrepreneurial Competence

As mentioned, scholars emphasise the combination of cognitive, social and emotional components in the learning process within entrepreneurship education. We provide examples of eye-tracking research in education that focus on each of these components, starting with the least explored one.

6.1.2 Emotional Component

The emotional aspects of learning belong to the least studied ones at the present time. A major number of studies concern emotional design in multimedia learning (as part of cognitive-affective theory of learning with media; Moreno & Mayer, 2007). For example, Park et al. (2015) reported that positive emotions associated with the learning material improved learning outcome in terms of comprehension and transfer. Similarly, Stark et al. (2018) used eye-tracking data to investigate learners' engagement with the instructional materials as well as their emotional states with self-reporting to draw conclusions about the influence of emotional text design on learning and learner's emotional state. It was found that both emotional designs

(positive and negative) led to better learning outcomes, as well as that emotional design assisted the elaboration process, but supressed metacognition. The positive emotional design had no effect on learners' emotional state, whereas negative design led to a worse emotional state in learners. A related line of research focused on how imposed mood influenced students' learning: students with imposed positive mood showed longer and more effective processing of scientific texts that led to higher learning outcomes (Scrimin & Mason, 2015).

Another potential possibility is to explore the emotional response of students in different situations by means of eye tracking and pupillometry. A recent work (Liu, Tao, & Gui, 2019) looked into the ways to use eye tracking to identify participants' emotional states during task completion, when the pupil size signalled the difficulty of the task and the blink rate—the level of concentration on it.

6.1.3 Social/Collaborative Component

The modern mobile eye tracker technology records data through several channels – the gaze tracking itself, the scene camara video recording and the audio recording of speech. Several recent studies show how these data can be used for analysing the classroom interaction in detail. Salminen-Saari et al. (2021) studied phases of student collaborative learning during a mathematical problem-solving task. Analysing data from mobile eye trackers, classroom video recordings and smart pen devices helped researchers to map the collaborative interaction where the phases of verifying, watching and listening were prevalent. The ways to differentiate successful collaborations on the basis of joint attention were also identified. Rosengrant et al. (2021) studied undergraduates' sustained attention during interactive enquiry-based classes. It was a longitudinal study where 17 students wore a mobile eye tracker over several semesters. The results showed that students stayed on-task the majority of the recorded time, and authors linked this high rate to the inquiry-based type of instruction. Haataja et al. (2021) investigated the role of the eye contact between teachers and students in the classroom interaction during problem-solving group work in the mathematics lesson. Both teachers and students wore mobile eye trackers; also video recording was present in the classroom. The data analysis was guided by interpersonal theory and revealed that eye contact was highly situational: students-initiated eye contact when teachers demonstrated communion, while teachers engaged in eye contact more when showing authority. In entrepreneurship education, students often collaborate with peers and the teacher, and the eye-tracking technology could help to map this interaction.

6.1.4 Cognitive Component

Focusing on the process of learning allows gaining insight on the fine-grained, incremental level, which can be informative for researchers and teachers. This can be approached through understanding learning and monitoring learning.

From the perspective of understanding learning, being able to see the incremental process of how students approach tasks when working on their project allows teachers to know how students learn, but also whether they learn what teachers expect them to. In the study of da Silva Soares et al. (2021), where teachers were presented with heatmaps that reflected students' strategies in approaching mathematical tasks, teachers pointed out that they had a different idea of students' strategies than the ones demonstrated. Schindler and Lilienthal (2020) reported a case study of a student solving a mathematical task while his gaze was tracked. The gaze pattern recording was used in a retrospective session where the student provided explanations for his actions. This allowed to develop a tentative model for the mathematical creative process that was distinct from existing models. The unique side of this study was using the mobile eye tracking that allowed the student to solve the task with pen and paper to preserve the authentic settings for the process (Schindler & Lilienthal, 2020). In entrepreneurship education, students often learn by doing (McCallum et al., 2018) and are offered techniques and models for analysis and reasoning, such as SWOT analysis, design thinking, business model canvas, etc. (Lackeus, 2015). Following the learners' reasoning when applying such tools could be a possibility to see their approach and line of thought when designing business models.

From the perspective of monitoring learning, on a more general level questions regarding student attention focus and experienced difficulty during tasks could be answered with the help of learning analytics. The term learning analytics defines extraction of meaning from learning-related data (Jaakonmäki et al., 2020). It can be used for optimising learning and teaching based on data-driven measurements and predictions and making the educational process more transparent (Jaakonmäki et al., 2020). Stracke and Skuballa (2021) proposed to apply eye tracking on different levels of education as a data collection and diagnostic tool within an emerging evaluation framework: for insights about teacher work and instructional materials at the micro- and meso-levels, and for making decisions about those on the macro-level policy level.

6.1.5 Multimodal Data Collection

Especially informative and inherently more complex information can be collected when eye tracking is part of multimodal data collection, that is, objective and subjective data from a number of channels from learners (Järvelä et al., 2021). The sources of data may include self-reporting, such as questionnaires; behavioural data, such as performance measures; computer logs, such as mouse clicks; psychophysiological and physiological indicators, such as eye tracking, skin conductance, heart rate and accelerometery; and first- and third-person video recordings (Wiedbusch et al., 2021; van Leeuwen et al., 2017; Prieto et al., 2016). For research purposes, indices of arousal, cognitive load and experienced difficulties can be extracted from these data. They can largely inform research on self-regulated learning of students. The multimodal data help record cyclical and temporal processes, as well as

activation of regulation, important for capturing self-regulated learning phases, and indicate critical moments in collaborative learning (Järvelä et al., 2021). Besides, these data can be collected as part of multimodal learning analytics (MMLA) and visualised on a dashboard to inform teachers and enable intervention.

6.2 *Research on Teaching: Contributing to Development of Teacher Expertise*

6.2.1 Teachers' Professional Vision

The application of eye tracking has founded a new model for teaching research that can greatly inform teacher education, in the teaching of entrepreneurship and beyond. Studies within the expert-novice paradigm utilised video-based and real-life teaching conditions in the laboratory and authentic settings. These studies underlined the aspects of teacher visual expertise for classroom management (van den Bogert et al., 2014), teacher priorities, the impact of the cultural context (McIntyre, 2016), as well as teachers' focus of attention (Muhonen et al., 2020), and interpersonal behaviour (Haataja et al., 2021) in general. These aspects are hard to investigate with the help of self-reporting methods but are becoming more relevant as entrepreneurship education started moving from higher education downwards to general K12 education—echoing European Union's targeted renaissances of entrepreneurship (Lindner, 2018).

Teachers' professional vision is regarded as teachers' ability to notice and interpret classroom events that are relevant to various aspects in the process of learning (Goodwin, 1994; van Es & Sherin, 2002). Borko and Putnam (1996) suggested that teacher knowledge underlying effective teaching includes content knowledge (understanding the concepts and disciplines of subject matter to be taught), general pedagogical knowledge (knowledge on the nature of learning) and pedagogical content knowledge (how to best explain content knowledge to students and awareness of students' potential misconceptions). Effective teachers, or expert teachers, however, show superior performance in skill sets (Forzani, 2014) of teaching such as classroom management, instructional explanations and formative assessment—represented in their more elaborated and coherently organised knowledge structures with accumulated teaching experiences (Krauss et al., 2008). When teacher knowledge overlaps with the superior performance skill set of expert teachers, these 'curriculum scripts' allow teachers to make instant, meaningful, informed and flexible teaching decisions in classrooms (Putnam, 1987). The ultimate goal, once again, is for practitioners and researchers to effectively design, evaluate and improve teaching and learning.

In addition to the possibility to advance the understanding of teachers' visual expertise in general, eye tracking can help be a part of teacher education via:

- Training pre-service teachers for classroom work through EMME and discussion of the model's gaze
- Recording pre-service teachers' classroom video and eye-tracking data for assessment and reflection-guiding purposes (Coskun & Cagiltay, 2021)
- Developing country-specific resources based on the findings from classroom eye-tracking research in relation to a certain teacher competence (Faiella et al., 2019)

However, for eye-tracking application to have direct and solid implications on teacher training, it is important to be reminded by McMahon et al. (2019) on the perpetual tension between research on teaching and teaching practices in real life, where teacher training needs to construct life-long professional learning skills that would sustain effective practices within the ever-changing classroom. Teacher training cannot be simplified into a set of skills with routines to be re-enacted inside the classroom. For teaching to be theoretically informed on bases of needs of individuals and groups of learners, how contexts where learners can flourish is to be created is an art form that can be transferred from the experts to the (relatively) novice teacher. This is true when the intensions of entrepreneurship education is either on *learning for entrepreneurship* (obtaining relevant knowledge and skills) or *learning about entrepreneurship* (obtaining general theoretical understanding), right before learners enter the stage of *learning through entrepreneurship* (experiential, entrepreneurial learning process) (Kyrö, 2005). Here, EMME is a valuable tool to be embedded into established methods of teaching as an expertise training. EMME episodes can be filled in when the tasks include visual aspects where studying the eye movement of an expert can offer insights as an elaborated model to design a curriculum for multifaceted issues, as suggested by Jarodzka et al. (2017).

7 Challenges in Eye-Tracking-Based Research

As innovative as it is, application of eye-tracking technology in education settings may still be challenging for researchers. Especially when starting with the method, researchers need time to get acquainted with the hardware and software principles, various eye-tracking measures and running pilot studies. This may often require a team of researchers, so the method may not be always feasible for individual researchers.

7.1 Hardware and Data Collection

Despite the recent advancement in the eye-tracking technology, limitations and specificities of the hardware remain in place and affect the research. Many studies reviewed in this chapter reported loss of data at some point of data collection caused

by de-calibration, malfunction, eye tracker and screen ratio incompatibility, participants looking beyond the eye tracker viewing angle or individual participant characteristics. Utilising eye-tracking technology always implies accounting for possible data loss.

7.2 Data Analysis

A common limitation in reported studies is a limited sample. This may be due to the case study design (van Leeuwen et al., 2017), eye tracker cost (Rosengrant et al., 2021) and difficulty of data processing (Stahnke & Blömeke, 2021). Due to intensive eye-tracking data analysis, researchers may lack possibilities to analyse all the data collected (McIntyre, 2016) or include more points for analysis in the study (Clinton et al., 2017). The time for publishing may increase as well. On the other hand, one study may yield enough data for several analyses and possibilities for data re-examination (Goldberg et al., 2021).

7.3 Chosen Measures of Analysis and Research Conditions Influence the Outcome

The choice of the measures applied to analysing the data directly affects the analysis outcome. For example, McIntyre and Foulsham (2018) provided event-based scanpath analysis and noted that a duration-based analysis could have led to different results. Also, study settings may affect the research results. Studies that examined novice teachers gaze behaviour by demonstration of classroom video recording, and those carried out during a real-life lesson (Goldberg et al., 2021) showed different results in respect to novice teachers' attention to student misbehaviour: video-based studies showed that novice teachers paid attention to students' disruptive behaviour, while in real classroom conditions, novice teachers tended to avoid looking at misbehaving or uninterested students and concentrated on those who followed the instruction. Goldberg et al. (2021) noted that these differences were due to how likely the participants assessed the chance to directly take action regarding student misbehaviour.

7.4 Interpreting Cognitive Processes

Defining and interpreting the cognitive process behind the gaze is not simple. What participants look at does not always coincide with what they process (Rayner, 2009), and there can be different reasons for participants to fixate on an area: it can be

difficult, relevant to the task or attractive (Orquin & Holmqvist, 2018). Thus, if think aloud recording is not available, what researchers see and interpret in the data can differ from where participants allocated their covert attention. This is a major limitation in eye-tracking research and some studies indicate it as such. Literature reviews on eye tracking in education (Alemdag & Cagiltay, 2018; Lai et al., 2013) also pointed out a need for examining the connection between eye movement measures and behaviour measures in addition to the general recommendation to clearly state the gaze-cognition assumption for every study (Fiedler et al., 2019).

7.5 Limitations of Additional Methods

When several data collection methods are employed and data triangulation can be made, a sound procedure applies to non-eye tracking data collection as well, with notice that each of the complementing methods has limitations on its own. For example, the cued retrospective reporting approach should elicit information about participants' cognitive processes by guiding and not interrupting participants' remembering (Pouta et al., 2021). At the same time, cued retrospective reporting can focus only on some of the complex elements of teaching and teachers' vision (Pouta et al., 2021). An example of how verbal data collection can influence the study outcome is the usage of post hoc think-aloud verbalisation in the study of Wyss et al. (2021). The teacher participants were asked to view a clip from a classroom that contained a 'critical incident' and report what they saw. Only 6 out of 56 participants noticed the incident and did not try to interpret it. The researchers noted that this could be caused by researchers encouraging participants to say what was *seen* without giving a direct prompt for interpretation.

7.6 Newness of the Method and Ethical Issues

Although eye tracking has a detailed history in different domains, it is a rather new method in educational research. If other domains concentrate on participants' involvement with media, such as user interface design, or even reading, educational science has moved the eye trackers to real-life classroom, with the complex interactions, dynamic environment and unpredictability of variables. This led to the emergence of new research designs that require a new methodological and theoretical consensus respectively (Jarodzka et al., 2021). Other facets of moving research into the classroom include recruitment of participants, novelty effect and ethical issues. First of all, teachers and students may be reluctant to take part in the data collection sessions that involve video recording and eye tracking. Rosengrant et al. (2021) provided an illustration to this – in their study, only one instructor agreed to have their lessons recorded by mobile eye tracker worn by students. At the same time, when relying only on participants who volunteered to take part in the study

themselves, self-selection bias may appear (Stahnke & Blömeke, 2021). Along with that, introducing new data collecting equipment in the classroom directly may create a novelty effect and change the behaviour of the participants (Faiella et al., 2019). Additionally, privacy-related ethical issues arise. Classroom recordings concern all students and teachers present in the classroom. This implies recording and storing a large amount of data from a high number of participants, including minors, and difficulties for initiating the research due to the numerous consents that need to be collected by researchers (Jarodzka et al., 2021). Besides, depending on the study purposes, eye-tracking data may include sensitive information, such as data on learning difficulties, which should not be accessed by third parties (Liu, Xia, et al., 2019). Thus, researchers need to be extra careful when collecting, storing and analysing the eye-tracking data.

8 Implications of Eye-Tracking Application on Entrepreneurship Education

In the specific case of entrepreneurship education, the direct application of eye-tracking technology can have implications on the increasing usage of multimedia in the teaching and learning of entrepreneurship. Ratten and Rashid (2021) suggested that integration of technological skills in the entrepreneurship curriculum can best prepare students for the international market as entrepreneurship relates directly to the rapidly changing business, market and products—entrepreneurship education needs to reflect on these constant changes to grow students into adoptive individuals with entrepreneur mindsets. The learning environments require modification to incorporate new era technologies and address up-to-date changes, while well-structured reflection on the digital nature of economics must be addressed in entrepreneurship education frameworks. While multimedia enriches teaching and learning of entrepreneurial concepts by providing more direct connections to real-life scenarios and maintaining students' motivation in class (Sudarwati et al., 2019), it is important to be reminded about the quality aspects of multimedia materials created and delivered through e-learning or on-line learning not taking into consideration the human cognition processes (Mudrick et al., 2019). Wu et al. (2021), too, explored the integration strategy of artificial intelligence and multimedia teaching in innovation and entrepreneurship education (IEE) in higher education, hindering the importance of ensuring appropriate access and engagement of multimedia content. Similarly, An and Xu (2021) identify on the connection between entrepreneurial education and vocational training as *entrepreneurship-oriented personnel training* in the form of maker education. The inevitable effects of the Internet of Things (IoT) and artificial intelligence (AI) technology on the construction of virtual Maker spaces in both K12 and higher education institutions both imply new platforms and methods of teaching and learning. This ensures that entrepreneurial education is highly practical and up-to-date. On this note, the design of virtual Maker spaces can

borrow from eye-tracking technology evaluations to ensure that instructional design issues are eliminated and both theoretical and practical learning materials are visually presented without distraction and optimise their function to support learning. Well-designed virtual learning materials and spaces will also allow a broader range of field experts with rich entrepreneurial backgrounds to be directly included in the assessment and evaluation process of entrepreneurial talent cultivation education (Zhong et al., 2020).

An interesting aspect of eye-tracking technology application to entrepreneurship education relates to perhaps the more practical side of entrepreneurship, relating to digital entrepreneurship and digital marketing. Ratten and Rashid (2021) suggest that effective entrepreneurship education needs to incorporate tasks designed for students to mimic and understand the experiences of entrepreneurs to incorporate emotional and intellectual intelligence leading to greater forms of creativity. This idea of *mimicking* is worthy of further expansion in relation to EMME designs. Concepts of digital marketing can be borrowed to help users reach out to the maximum audience, creating awareness among users, and communicate with customers intelligently. The use of eye-tracking technology to improve marketing allows one to see things from the perspectives of the consumers to gain insight into what grabs attention, what influences purchasing behaviour and how consumers engage with products. Examples include shopper research, packaging research, advertising research and user experience (UX) research. While educational scholars explore new ways of delivering education, concepts can borrow from an almost identical foundation as the goals are, similarly, to attract student attention, trigger motivation and maintain engagement. This kind of cross-disciplinary mindset too echoes the core of entrepreneurship education by inviting students to find creative ways to reapply tools in response to modern-day problems or societal needs while exploring new opportunities.

Furthermore, the idea of *learning from the expert* in maker education is worth further exploring where it overlaps with the concept of eye-tracking application and professional vision. Early reviews on entrepreneurship education such as Solomon (2007) have long hindered the importance of teaching by involving experts. Learning in classrooms in this case can happen from both students and the teachers while engaging with entrepreneurs/entrepreneurship experts. Modern eye-tracking technology shines new light on this reminder as roles of teacher and students in learning environments may be reconsidered. However, limitations of eye-tracking technology applications on entrepreneurship education may also be due to contradictions on the fundamental difference in how to learn from the experts. The need to understand visual expertise relates to how professionals or experts perceive events and scenes from the expert domain difference from non-experts, in order to gain insights to how the experts notice and gain situational awareness (Endsley, 2015), leading to their cognitive process patterns. In entrepreneurship education, entrepreneurship is seen as competences that can be obtained, such as the attitude and ability to solve new problem with unknown answers (Núñez & Núñez, 2016). Seeing how previous problems have been solved by experts through the expert's eyes may offer case study-based insights but does not offer a model for learning the competencies to

become more entrepreneurial. This is particularly true when the entrepreneurial spirit refers 'a competence that is developed by each person who perseveres in fulfilling their motives, relinquishing stability to further develop themselves, others and their environment with passion, risk and sacrifice... (with) the desire to understand their (own) motivations... (and) seek and generate new opportunities to fulfil their motives, relying on their strong drive for achievement' (Arruti & Castro, 2021, p. 4). As eye tracking is based on the eye-mind hypothesis, or what is attended to by the eye is processed by the mind (Duchowski, 2007) which must be accompanied with stimulate recall to offer a fuller perspective on what we understand as professional vision, it is therefore important to cross-reference the selective attention—based on eye -tracking evident professional vision – and knowledge-based reasoning, based on verbal data or questionnaires (Minarikova et al., 2021). This allows students to both see and hear from the expert's processing in encountered problems, where both 'attention based on their reasoning, and reason about things they give attention to' (Sherin et al., 2011, p. 5) can both be observed either by the students or teachers looking to teach it. Eye-tracking technology can be complimentary in enriching entrepreneurship education.

9 Conclusions

The study on the application of eye tracking in educational research reveals that new technologies allow to expand our approaches to investigate learning and teaching process through different perspectives. Currently eye-tracking technology is used in numerous thematic areas, which were identified through this research: information processing, effects of instructional strategies, different individuals' learning styles, effects of learning strategies and patterns of decision-making.

Entrepreneurship education is a new filed where eye tracking can be applied. Existing research in educational sciences can inform this new direction with the proposed focus on learning and teaching. It can be recommended to concentrate on features of learning and teaching that are of higher significance specifically for entrepreneurship education, such as collaborative activities, decision-making and reasoning when working with specialised entrepreneurial tools.

For learning, eye tracking offers a micro-level objective observation of cognitive processes, interpersonal interactions and emotional responses. Regarding teaching, eye tracking is a way to connect the psychological and professional aspects, revealing the cognition and perception behind the teaching process. Still, there are limitations associated with the technology and a need for defining a new methodology for eye-tracking studies in real-life classrooms.

References

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes, 50*, 179–211.

Alemdag, E., & Cagiltay, K. (2018). A systematic review of eye tracking research on multimedia learning. *Computers & Education, 125*, 413–428. https://doi.org/10.1016/j.compedu.2018.06.023

An, H., & Xu, Y. (2021). Cultivation of entrepreneurial talents through virtual entrepreneurship practice in higher education institutions. *Frontiers in Psychology, 12*, 690692. https://doi.org/10.3389/fpsyg.2021.690692

Arruti, A. and Castro, J. (2021). Innovation and entrepreneurship in education, irreconcilable differences? A first approach through Spanish expert judgment. *International Journal of Innovation Science*, ahead-of print. https://doi.org/10.1108/IJIS-07-2020-0106

Bacigalupo, M., Kampylis, P., Punie, Y., & Van den Brande, G. (2016). *EntreComp: The entrepreneurship competence framework*. Publication Office of the European Union. https://doi.org/10.2791/593884

Bandura, A. (1977). *Social learning theory*. Prentice-Hall.

Bolden, D., Barmby, P., Raine, S., & Gardner, M. (2015). How young children view mathematical representations: A study using eye-tracking technology. *Educational Research, 57*(1), 59–79. https://doi.org/10.1080/00131881.2014.983718

Borko, H., & Putnam, R. (1996). Learning to teach. In D. Berliner & R. Calfee (Eds.), *Handbook of educational psychology* (pp. 673–708). Macmillan.

Boshuizen, H. P. A., & Schmidt, H. G. (1992). On the role of biomedical knowledge in clinical reasoning by experts, intermediates, and novices. *Cognitive Science, 16*(2), 153–184. https://doi.org/10.1207/s15516709cog1602_1

Chandler, P., & Sweller, J. (1991). Cognitive load theory and the format of instruction. *Cognition and Instruction, 8*(4), 293–332. https://doi.org/10.1207/s1532690xci0804_2

Christenson, S. L., Reschly, A. L., & Wylie, C. (Eds.). (2012). *Handbook of research on student engagement*. Springer. https://doi.org/10.1007/978-1-4614-2018-7

Clinton, V., Cooper, J. L., Michaelis, J. E., Alibali, M. W., & Nathan, M. J. (2017). How revisions to mathematical visuals affect cognition: Evidence from eye tracking. In C. Was, F. Sansosti, & B. Morris (Eds.), *Eye-tracking technology applications in educational research* (pp. 195–218). IGI Global. https://doi.org/10.4018/978-1-5225-1005-5.ch010

Coskun, A., & Cagiltay, K. (2021). Investigation of classroom management skills by using eye-tracking technology. *Education and Information Technologies, 26*(3), 2501–2522. https://doi.org/10.1007/s10639-020-10368-0

Crundall, D., Chapman, P., Trawley, S., Collins, L., van Loon, E., Andrews, B., & Underwood, G. (2012). Some hazards are more attractive than others. *Accident Analysis and Prevention, 45*, 600–609. https://doi.org/10.1016/j.aap.2011.09.049

da Silva Soares, R., Lukasova, K., Carthery-Goulart, M. T., & Sato, J. R. (2021). Student's perspective and teachers' metacognition: Applications of eye-tracking in education and scientific research in schools. *Frontiers in Psychology, 12*, 673615. https://doi.org/10.3389/fpsyg.2021.673615

Dew, N., Read, S., Sarasvathy, S. D., & Wiltbank, R. (2009). Effectual versus predictive logics in entrepreneurial decision-making: Differences between experts and novices. *Journal of Business Venturing, 24*(4), 287–309. https://doi.org/10.1016/j.jbusvent.2008.02.002

Drusch, G., Bastien, J. M. C., & Paris, S. (2014). Analysing eye-tracking data: From scanpaths and heatmaps to the dynamic visualisation of areas of interest. *International Conference on Applied Human Factors and Ergonomics, Krakow, Poland*. Retrieved from: https://hal.archives-ouvertes.fr/hal-01223743/document

Duchowski, A. T. (2007). *Eye tracking methodology: Theory and practice* (2nd ed.). Springer.

Endsley, M. R. (2015). Situation awareness misconceptions and misunderstandings. *Journal of Cognitive Engineering and Decision Making, 9*, 4–32. https://doi.org/10.1177/1555343415572631

Ericsson, K. A., Charness, N., Feltovich, P., & Hoffman, R. R. (Eds.). (2006). *The Cambridge handbook of expertise and expert performance*. Cambridge University Press.

Ericsson, K. A., & Kintsch, W. (1995). Long-term working memory. *Psychological Review, 102*(2), 211–245. https://doi.org/10.1037/0033-295X.102.2.211

Ericsson, K. A., & Lehmann, A. C. (1996). Expert and exceptional performance: Evidence of maximal adaption to task constraints. *Annual Reviews in Psychology, 47*(1), 273–305. https://doi.org/10.1146/annurev.psych.47.1.273

Faiella, F., Mannese, E., Savarese, G., Plutino, A., & Lombardi, M. G. (2019). Eye-tracking glasses for improving teacher education: The e-teach project. *Research on Education and Media, 11*(1), 85–92. https://doi.org/10.2478/rem-2019-0012

Fiedler, S., Schulte-Mecklenbeck, M., Renkewitz, F., & Orquin, J. L. (2019). Increasing reproducibility of eye-tracking studies. In M. Schulte-Mecklenbeck, A. Kuehberger, & J. G. Johnson (Eds.), *A handbook of process tracing methods* (2nd ed.). Routledge. https://doi.org/10.4324/9781315160559

Forzani, F. M. (2014). Understanding "Core practices" and "practice-based" teacher education: Learning from the past. *Journal of Teacher Education, 65*, 357–368. https://doi.org/10.1177/0022487114533800

Gartner, W. B. (1990). What are we talking about when we talk about entrepreneurship? *Journal of Business Venturing, 5*, 15–28.

Gibb, A. (1993). Enterprise culture and education: Understanding enterprise education and its links with small business, entrepreneurship and wider educational goals. *International Small Business Journal, 11*(3), 11–34.

Goldberg, P., Schwerter, J., Seidel, T., Müller, K., & Stürmer, K. (2021). How does learners' behavior attract preservice teachers' attention during teaching? *Teaching and Teacher Education, 97*, 103–213. https://doi.org/10.1016/j.tate.2020.103213

Goodwin, C. (1994). Professional vision. *American Anthropologist, New Series, 96*(3), 606–633. https://doi.org/10.1525/aa.1994.96.3.02a00100

Haataja, E., Salonen, V., Laine, A., Toivanen, M., & Hannula, M. S. (2021). The relation between teacher-student eye contact and teachers' interpersonal behavior during group work: A multiple-person gaze-tracking case study in secondary mathematics education. *Educational Psychology Review, 33*(1), 51–67. https://doi.org/10.1007/s10648-020-09538-w

Haider, H., & Frensch, P. (1999). Information reduction during skill acquisition: The influence of task instruction. *Journal of Experimental Psychology: Applied, 5*(2), 129–151. https://doi.org/10.1037/1076-898X.5.2.129

Holmqvist, K., Nyström, M., Andersson, R., Dewhurst, R., Jarodzka, H., & Van de Weijer, J. (2011). *Eye tracking: A comprehensive guide to methods and measures*. Oxford University Press.

Jaakonmäki, R., vom Brocke, J., Dietze, S., Drachsler, H., Fortenbacher, A., Helbig, R., Kickmeier-Rust, M., Marenzi, I., Suarez, A., & Yun, H. (2020). Learning analytics kitchen. In R. Jaakonmäki, J. vom Brocke, S. Dietze, H. Drachsler, A. Fortenbacher, R. Helbig, M. Kickmeier-Rust, I. Marenzi, A. Suarez, & H. Yun (Eds.), *Learning analytics cookbook: How to support learning processes through data analytics and visualization* (pp. 7–14). Springer International Publishing. https://doi.org/10.1007/978-3-030-43377-2_2

Jarodzka, H., Holmqvist, K., & Gruber, H. (2017). Eye tracking in educational science: Theoretical frameworks and research agendas. *Journal of Eye Movement Research, 10*(1), 10.16910/jemr.10.1.3.

Jarodzka, H., Skuballa, I., & Gruber, H. (2021). Eye-tracking in educational practice: Investigating visual perception underlying teaching and learning in the classroom. *Educational Psychology Review, 33*(1), 1–10. https://doi.org/10.1007/s10648-020-09565-7

Jarodzka, H., van Gog, T., Dorr, M., Scheiter, K., & Gerjets, P. (2013). Learning to see: Guiding students' attention via a Model's eye movements fosters learning. *Learning and Instruction, 25*, 62–70. https://doi.org/10.1016/j.learninstruc.2012.11.004

Järvelä, S., Malmberg, J., Haataja, E., Sobocinski, M., & Kirschner, P. A. (2021). What multimodal data can tell us about the students' regulation of their learning process? *Learning and Instruction, 72*, 101–203. https://doi.org/10.1016/j.learninstruc.2019.04.004

Johannisson, B. (2018). Limits to and prospects of entrepreneurship education in the academic context. In A. Fayolle (Ed.), *A research agenda for entrepreneurship education* (pp. 139–163). Edward Elgar Publishing. https://doi.org/10.4337/9781786432919.00014

Kaakinen, J. K. (2021). What can eye movements tell us about visual perception processes in classroom contexts? Commentary on a special issue. *Educational Psychology Review, 33*(1), 169–179. https://doi.org/10.1007/s10648-020-09573-7

Kalyuga, S. (2007). Expertise reversal effect and its implications for learner-tailored instruction. *Educational Psychology Review, 19*, 509–539. https://doi.org/10.1007/s10648-007-9054-3

Kirschner, P. A., Sweller, J., & Clark, R. E. (2006). Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. *Educational Psychologist, 41*(2), 75–86. https://doi.org/10.1207/s15326985ep4102_1

Kok, E., Jarodzka, H., De Bruin, A. B. H., BinAmir, H., Robben, S. G. F., & Van Merriënboer, J. J. G. (2015). Systematic viewing in radiology: Seeing more, missing less? *Advances in Health Science Education, 21*(1), 189–205. https://doi.org/10.1007/s10459-015-9624-y

Komarkova, I., Gagliardi, D., Conrads, J., & Collado, A. (2015). *Entrepreneurship competence: An overview of existing concepts, policies and initiatives - final report*. Publications Office of the European Union.

Krauss, S., Brunner, M., Kunter, M., Baumert, J., Blum, W., Neubrand, M., et al. (2008). Pedagogical content knowledge and content knowledge of secondary mathematics teachers. *Journal of Education & Psychology, 100*(3), 716–725. https://doi.org/10.1037/0022-0663.100.3.716

Kyrö, P. (2005). Entrepreneurial learning in a cross-cultural context challenges previous learning paradigms. In P. Kyrö & C. Carrier (Eds.), *The dynamics of learning entrepreneurship in a cross-cultural university context*. University of Tampere.

Kyrö, P. (2018). The conceptual contribution of education to research on entrepreneurship education. In A. Fayolle (Ed.), *A research agenda for entrepreneurship education* (pp. 164–186). Edward Elgar Publishing. https://doi.org/10.4337/9781786432919.00015

Lackeus, M. (2015). *Entrepreneurship in education: What, why, when, how*. OECD. Retrieved from https://www.oecd.org/cfe/leed/BGP_Entrepreneurship-in-Education.pdf

Lai, M.-L., Tsai, M.-J., Yang, F.-Y., Hsu, C.-Y., Liu, T.-C., Lee, S. W.-Y., Lee, M.-H., Chiou, G.-L., Liang, J.-C., & Tsai, C.-C. (2013). A review of using eye-tracking technology in exploring learning from 2000 to 2012. *Educational Research Review, 10*, 90–115. https://doi.org/10.1016/j.edurev.2013.10.001

Lans, T., Baggen, Y., & Ploum, B. (2018). Towards more synergy in entrepreneurial competence research in entrepreneurship education. In A. Fayolle (Ed.), *A research agenda for entrepreneurship education* (pp. 224–242). Edward Elgar Publishing. https://doi.org/10.4337/9781786432919.00018

Lindner, J. (2018). Entrepreneurship education for a sustainable future. *Discourse and Communication for Sustainable Education, 9*(1), 115–127. https://doi.org/10.2478/dcse-2018-0009

Liu, A., Xia, L., Duchowski, A., Bailey, R., Holmqvist, K., & Jain, E. (2019). Differential privacy for eye-tracking data. In *Proceedings of the 11th ACM Symposium on Eye Tracking Research & Applications* (pp. 1–10). https://doi.org/10.1145/3314111.3319823

Liu, S., Tao, X., & Gui, Q. (2019). Research on emotional state in online learning by eye tracking technology. In *Proceedings of the 2019 4th International Conference on Intelligent Information Processing* (pp. 471–477). https://doi.org/10.1145/3378065.3378154

Martin, J. T. (2019). Exploring cognition in visual search and vigilance tasks with eye tracking and pupillometry. Doctoral thesis, Swansea University. Retrieved from https://cronfa.swan.ac.uk/Record/cronfa53842

Mayer, R. E. (2009). *Multimedia learning*. Cambridge University Press.

McCallum, E., McMullan, L., Weicht, R., & Kluzer, S. (2020). In M. Bacigalupo (Ed.), *EntreComp at work. The European entrepreneurship competence framework in action in the labour market: A selection of case studies*. Publications Office of the European Union.

McCallum, E., Weicht, R., McMullan, L., & Price, A. (2018). In M. Bacigalupo & W. O'Keeffe (Eds.), *EntreComp into action: Get inspired, make it happen*. Publication Office of the European Union. https://doi.org/10.2760/574864

McIntyre, N. (2016). Teach at first sight: Expert teacher gaze across two cultural settings. Doctoral thesis, University of York. Retrieved from http://etheses.whiterose.ac.uk/15408

McIntyre, N. A., & Foulsham, T. (2018). Scanpath analysis of expertise and culture in teacher gaze in real-world classrooms. *Instructional Science, 46*(3), 435–455. https://doi.org/10.1007/s11251-017-9445-x

McMahon, K., Yeh, C. S.-H., & Etchells, P. J. (2019). The impact of a modified initial teacher education on challenging Trainees' understanding of Neuromyths. *Mind, Brain, and Education, 13*, 288–297. https://doi.org/10.1111/mbe.12219

Minarikova, E., Smidekova, Z., Janik, M., & Holmqvist, K. (2021). Teachers' professional vision: Teachers' gaze during the act of teaching and after the event. *Frontiers in Education.* https://doi.org/10.3389/feduc.2021.716579

Mitchell, R. K., Busenitz, L., Lant, T., McDougall, P. P., Morse, E. A., & Smith, J. B. (2004). The distinctive and inclusive domain of entrepreneurial cognition research. *Entrepreneurship Theory and Practice, 28*(6), 505–518. https://doi.org/10.1111/j.1540-6520.2004.00061.x

Moreno, R., & Mayer, R. (2007). Interactive multimodal learning environments. *Educational Psychology Review, 19*(3), 309–326.

Mudrick, N., Azevedo, R., & Taub, M. (2019). Integrating metacognitive judgments and eye movements using sequential pattern mining to understand processes underlying multimedia learning. *Computers in Human Behaviour, 96*, 223–234. https://doi.org/10.1016/j.chb.2018.06.028

Muhonen, H., Pakarinen, E., Rasku-Puttonen, H., & Lerkkanen, M.-K. (2020). Dialogue through the eyes: Exploring teachers' focus of attention during educational dialogue. *International Journal of Educational Research, 102*. https://doi.org/10.1016/j.ijer.2020.101607

Núñez, L., & Núñez, M. (2016). Nocion de emprendimiento Para una formacion escolaren competencia emprendedora. *Revista Latina de Comunicacion Social, 71*, 1069–1089. https://doi.org/10.4185/RLCS-2016-1135

Orquin, J. L., & Holmqvist, K. (2018). Threats to the validity of eye-movement research in psychology. *Behavior Research Methods, 50*(4), 1645–1656. https://doi.org/10.3758/s13428-017-0998-z

Park, B., Knörzer, L., Plass, J. L., & Brünken, R. (2015). Emotional design and positive emotions in multimedia learning: An eyetracking study on the use of anthropomorphisms. *Computers & Education, 86*, 30–42.

Pittaway, L., & Cope, J. (2007). Entrepreneurship education: A systematic review of the evidence. *International Small Business Journal: Researching Entrepreneurship, 25*(5), 479–510. https://doi.org/10.1177/0266242607080656

Pouta, M., Lehtinen, E., & Palonen, T. (2021). Student teachers' and experienced teachers' professional vision of students' understanding of the rational number concept. *Educational Psychology Review, 33*(1), 109–128. https://doi.org/10.1007/s10648-020-09536-y

Prieto, L. P., Sharma, K., Dillenbourg, P., & Jesús, M. (2016). Teaching analytics: Towards automatic extraction of orchestration graphs using wearable sensors. In *Proceedings of the sixth international conference on Learning Analytics & Knowledge - LAK '16* (pp. 148–157). https://doi.org/10.1145/2883851.2883927

Putnam, R. T. (1987). Structuring and adjusting content for students: A study of live and simulated tutoring of addition. *American Educational Research Journal, 24*(1), 13–48. https://doi.org/10.3102/00028312024001 01

Ratten, V., & Rashid, S. (2021). Entrepreneurship education and digital marketing: What does the future hold? In P. Thaichon & V. Ratten (Eds.), *Developing Digital Marketing* (pp. 87–101). Emerald Publishing Limited. https://doi.org/10.1108/978-1-80071-348-220211006

Rayner, K. (2009). The 35th sir Frederick Bartlett lecture: Eye movements and attention in reading, scene perception, and visual search. *Quarterly Journal of Experimental Psychology, 62*(8), 1457–1506. https://doi.org/10.1080/17470210902816461

Reingold, E. M., & Sheridan, H. (2011). Eye movements and visual expertise in chess and medicine. In S. P. Liversedge, I. D. Gilchrist, & S. Everling (Eds.), *Oxford handbook of eye movements* (pp. 523–550). Oxford University Press.

Richardson, D. C., & Dale, R. (2005). Looking to understand: The coupling between speakers' and listeners' eye movements and its relationship to discourse comprehension. *Cognitive Science, 29*(6), 1045–1060. https://doi.org/10.1207/s15516709cog0000_29

Rosengrant, D., Hearrington, D., & O'Brien, J. (2021). Investigating student sustained attention in a guided inquiry lecture course using an eye tracker. *Educational Psychology Review, 33*(1), 11–26. https://doi.org/10.1007/s10648-020-09540-2

Ruskovaara, E., & Pihkala, T. (2015). Entrepreneurship education in schools: Empirical evidence on the Teacher's role. *The Journal of Educational Research, 108*(3), 236–249. https://doi.org/10.1080/00220671.2013.878301

Salminen-Saari, J. F. A., Garcia Moreno-Esteva, E., Haataja, E., Toivanen, M., Hannula, M. S., & Laine, A. (2021). Phases of collaborative mathematical problem solving and joint attention: A case study utilizing mobile gaze tracking. *ZDM – Mathematics Education, 53*(4), 771–784. https://doi.org/10.1007/s11858-021-01280-z

Sarasvathy, S. D. (2001). Causation and effectuation: Toward a theoretical shift from economic inevitability to entrepreneurial contingency. *The Academy of Management Review, 26*(2), 243–263.

Schank, R. C., & Abelson, R. P. (2013). *Scripts, plans, goals, and understanding: An inquiry into human knowledge structures*. Lawrence Erlbaum Associates.

Schindler, M., & Lilienthal, A. J. (2020). Students' creative process in mathematics: Insights from eye-tracking-stimulated recall interview on students' work on multiple solution tasks. *International Journal of Science and Mathematics Education, 18*(8), 1565–1586. https://doi.org/10.1007/s10763-019-10033-0

Scrimin, S., & Mason, L. (2015). Does mood influence text processing and comprehension? Evidence from an eye-movement study. *British Journal of Educational Psychology, 85*(3), 387–406. https://doi.org/10.1111/bjep.12080

Sherin, M. G., Jacobs, V. R., & Philipp, R. A. (2011). *Mathematics teacher noticing: Seeing through teachers' eyes*. Routledge. https://doi.org/10.4324/9780203832714

Solomon, G. (2007). An examination of entrepreneurship education in the United States. *Journal of Small Business and Enterprise Development, 14*, 168–182. https://doi.org/10.1108/14626000710746637

Stahnke, R., & Blömeke, S. (2021). Novice and expert teachers' noticing of classroom management in whole-group and partner work activities: Evidence from teachers' gaze and identification of events. *Learning and Instruction, 74*, 101464. https://doi.org/10.1016/j.learninstruc.2021.101464

Stark, L., Brünken, R., & Park, B. (2018). Emotional text design in multimedia learning: A mixed-methods study using eye tracking. *Computers & Education, 120*, 185–196. https://doi.org/10.1016/j.compedu.2018.02.003

Stracke, C. M., & Skuballa, I. T. (2021). Using, analyzing and evaluating eye-tracking at different educational levels: Towards an evaluation framework for impact assessment. *TEM Journal, 10*(2), 483–487. https://doi.org/10.18421/TEM102-01

Sudarwati, N., Rukminingsih and Prianto, A. (2019, November 23). The use of multimedia in teaching entrepreneurship for university students: The case of economic education students. [Paper presentation]. J. Phys.: Conf. Ser. 1511 012014: *International Conference on Science Education and Technology (ICOSETH)*, Surakarta, Indonesia https://doi.org/10.1088/1742-6596/1511/1/012014.

Tittel, A., & Terzidis, O. (2020). Entrepreneurial competences revised: Developing a consolidated and categorized list of entrepreneurial competences. *Entrepreneurship Education, 3*(1), 1–35. https://doi.org/10.1007/s41959-019-00021-4

van den Bogert, N., van Bruggen, J., Kostons, D., & Jochems, W. (2014). First steps into understanding teachers' visual perception of classroom events. *Teaching and Teacher Education, 37*, 208–216. https://doi.org/10.1016/j.tate.2013.09.001

van Es, E. A., & Sherin, M. G. (2002). Learning to notice: Scaffolding new teachers' interpretations of classroom interactions. *Journal of Technology and Teacher Education, 10*(4), 571–596.

van Leeuwen, A., van Wermeskerken, M., Erkens, G., & Rummel, N. (2017). Measuring teacher sense making strategies of learning analytics: A case study. *Learning: Research and Practice, 3*(1), 42–58. https://doi.org/10.1080/23735082.2017.1284252

van Lehn, K. (1996). Cognitive skill acquisition. *Annual Review of Psychology, 47*, 513–539. https://doi.org/10.1146/annurev.psych.47.1.513

Wade, N. J., & Tatler, B. W. (2005). *The moving tablet of the eye: The origins of modern eye movement research*. Oxford University Press. https://doi.org/10.1093/acprof:oso/9780198566175.001.0001

Welsh, D. H. B., Tullar, W. L., & Nemati, H. (2016). Entrepreneurship education: Process, method, or both? *Journal of Innovation & Knowledge, 1*(3), 125–132. https://doi.org/10.1016/j.jik.2016.01.005

Wiedbusch, M. D., Kite, V., Yang, X., Park, S., Chi, M., Taub, M., & Azevedo, R. (2021). A theoretical and evidence-based conceptual design of MetaDash: An intelligent teacher dashboard to support teachers' decision making and students' self-regulated learning. *Frontiers in Education, 6*. https://doi.org/10.3389/feduc.2021.570229

Wu, D., Shen, H., & Lv, Z. (2021). An artificial intelligence and multimedia teaching platform based integration path of IPE and IEE in colleges and universities. *Journal of Intelligent & Fuzzy Systems, 40*(2), 3767–3776. https://doi.org/10.3233/JIFS-189410

Wyss, C., Rosenberger, K., & Bührer, W. (2021). Student teachers' and teacher educators' professional vision: Findings from an eye tracking study. *Educational Psychology Review, 33*(1), 91–107. https://doi.org/10.1007/s10648-020-09535-z

Xie, H., Zhao, T., Deng, S., Peng, J., Wang, F., & Zhou, Z. (2021). Using eye movement modelling examples to guide visual attention and foster cognitive performance: A meta-analysis. *Journal of Computer Assisted Learning, 37*(4), 1194–1206. https://doi.org/10.1111/jcal.12568

Zhong, H., Yan, R., Li, S., & Chen, M. (2020). The psychological expectation of new project income under the influence of the Entrepreneur's sentiment from the perspective of information asymmetry. *Frontiers in Psychology, 11*, 1416. https://doi.org/10.3389/fpsyg.2020.01416