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Jumping from one resource to another: how do students navigate learning networks?

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Abstract

A considerable amount of literature has recently appeared around the theme of learning networks and Connectivism. However, our understanding of how and why students navigate learning networks in the way they do is limited and the field lacks empirical studies investigating how students form connections. This paper presents a model showing how students form connections to different kinds of resources, along with the criteria they use to decide on which resource to choose. The findings were derived by conducting retrospective think-aloud sessions with nine participants after solving 10 tasks each. Mixed-methods approach was used in the data analysis. A goal of this research is to contribute to a deeper understanding of the navigation processes in learning networks and to provide guidance for online learning practitioners who seek to improve their practices.

Keywords: Connectivism, Networked learning, Learning networks, Online learning, Educational technology, Internet, ICT, Information and communication technology

Introduction

Studying networked learning or learning networks has gained momentum recently. Educators around the globe are striving to figure out the best way to make use of the recent technological revolution in enhancing student performance. However, the design for learning networks has yet to be recognized (Czerkawski, 2016). Furthermore, the debate amongst scholars continues about the one concept that ought to be the clearest: the definition of 'networked learning'.

Despite this debate, the researcher argues that Connectivism provides a promising framework to study the networked learning phenomenon (AlDahdouh, 2017; AlDahdouh et al., 2015; Downes, 2006, 2007; Siemens, 2005). The idea of Connectivism lies in its presumption that knowledge has a structure and it is best conceived as a network. According to this emerging theory, a network is a set of nodes connected by relationships. The *node* refers to any object that can be connected to another object (i.e. person, book, webpage, mobile application, thought, idea). In Connectivism, students are seen as nodes in a network. The theory assumes that when students establish a *connection* with other nodes, they consult or refer to those nodes (e.g. recall an idea or thought, read a book, ask their friends). A clear distinction between node types is that some are *internal* (inside the student's mind, such as ideas and thoughts) or *external* (such as books and people).

In a previous investigation of Connectivism (AlDahdouh, 2017; AlDahdouh et al., 2015), it was shown that Connectivism lacks a clear explanation of how a connection is formed. Furthermore, Verhagen (2006) argued that Connectivism presents a pedagogical view of education and not a learning theory mainly because it does not clarify *how* learning takes place. In addition, Clarà and Barberà (2014), who identified three problems with connectivist conception of learning, questioned "When a pattern is connected for the first time, why are the nodes connected in that specific way, and why is that configuration seen as a pattern?" (p. 12). Connectivists recognized this gap and proposed a theoretical framework for exploring questions such as: "How are connections formed" (Dunaway, 2011, p. 677)? The purpose of this study is to answer these questions.

Networked learning and Connectivism

Networked learning is often defined as technologically mediated learning, where information and communication technologies (ICT) facilitate the process of creating connections between people, content, resources and tools (Czerkawski, 2016). Goodyear, Banks, Hodgson, and McConnell (2004) presented and defined networked learning as the learning process in which ICT *promotes* the creation of connections. It promotes – but does not mediate – the interaction because a networked learning exists even in the absence of ICT (Czerkawski, 2016). Connectivism also conforms to the role of ICT in one of its principles: "Knowledge may reside in non-human appliances, and learning is enabled/facilitated by technology" (Siemens, 2006b, p. 31).

While some theorists (Goodyear et al., 2004; Siemens, 2006b) have tried not to exaggerate the role of ICT in student's learning, others theorists (Downes, 2007) and most practitioners (Drexler, 2010; Wang, Anderson, & Chen, 2018) have amplified the importance of ICT. Downes (2007), for example, asserted that "A network is a collection of connected entities, where a connection is something that allows one entity to send a signal to another entity. The internet is a network; it connects computers together and allows their operators to send messages to each other. And as we have seen, the users of Web 2.0 applications organize themselves into a network as well" (p. 8). Furthermore, in her experiment, Drexler (2010, p. 379) acknowledged that students can access traditional textbooks. However, she identified the success of her project based on whether personal learning environments (PLE) succeeded in 'replacing' the traditional textbook.

It is without question that ICT helps us in communicating, sharing, and discussing our thoughts but our conceptual understanding of learning networks should not be limited to such a strict view of the role of technology as a mediator. The internet is a network (Downes, 2007), but does this mean that a student who interacts with his friends face-to-face, reads a book at the library, or asks his teacher a question cannot be viewed as participating in learning networks? Our conceptual framework goes beyond this deficient vision and extends the analysis of learning networks to include technology-mediated and un-mediated interaction.

In Connectivism, the structure of knowledge itself is a network (AlDahdouh, 2017; AlDahdouh et al., 2016; AlDahdouh et al., 2015; Downes, 2008a; Siemens, 2006b). Connectivism recognizes that knowledge does not have a well-organized structure as it was assumed by Constructivism where each building block is placed on top of previous building blocks. Instead, knowledge has a chaotic structure so that each of its building block (e.g.

piece of information, an idea, a concept) can be connected virtually to any other building block. And this chaotic structure exists only in a network structure. The networked structure of knowledge from Connectivism's perspective was discussed thoroughly by AlDahdouh et al. (2015) and Downes (2008a).

Siemens and Tittenberger (2009) contended that knowledge and learning can be described as a network in three separate levels: the neural, conceptual and external levels. They argued that although these networks are separated, they share the same characteristics. The difference between them is only in their node type. Thus, at the neural level, the node is a neuron (AlDahdouh, 2017) while the node at the conceptual level is an idea, a thought or a concept. At the external level, the node could be a person, an information source, or any similar entity capable of being connected to. According to AlDahdouh et al. (2015), it is important to understand network sciences in order to understand Connectivism. Defining a network simply as a set of nodes, objects, or entities that are linked together with connections may need clarification. AlDahdouh et al.'s presentations have added concrete examples of Connectivism's abstract words by stating that although Connectivism pays attention to only those three levels of networks, the nodes in a knowledge network can be anything. A simple example of the external level is to see a student as a node in a social network (real or virtual). A student has relationships with his/her classmates as well as with his/her teachers. Those relationships are seen as connections. The connections are interpreted and graded and are not necessarily dichotomous variables (1 active and 0 inactive). A network does not have layers or a specific hierarchy (AlDahdouh, 2017); any node can connect to any other node. The node can even connect to itself (for more details, see AlDahdouh et al., 2015).

Another important concept in Connectivism is that a single connection between two nodes may not have meaning on its own. Rather, it is a collective set of connections, which usually have meaning. This collective set is called a "pattern". By zooming out in the network, one can conceive a network of nodes as a single whole which is then called either a pattern (if we still recognize the nodes and the connections in a lower level) or a node (if we blur the details and look at it from a higher level). That is to say that a consistent pattern of connections is a node, but at a higher level. For example, one can zoom out and conceive the whole class as a single node in a school network. In other words, each node is actually a network of nodes (Downes, 2016). The flow of information is what makes a pattern appear as such (AlDahdouh et al., 2015). The repetition of nerve impulses compels the neuron to connect to other neurons at the neural level; the information, events and experiences passing through one's thoughts makes a pattern of thoughts consistent at the conceptual level.

If we assume that knowledge structure is a network, then it is logical to see learning as a process of network formation. It is also logical to see that "the pipe is more important than the content within the pipe (simply because content changes rapidly)" (Siemens, 2006b, p. 32). The more a student is capable of connecting to specialized nodes, the better his/her position will be in the learning networks. This is because these connections would render the flow of information to and from the student easier and faster. According to Downes (2009) and Kop, Fournier, and Mak (2011), to learn in a connectivist environment, a learner should engage in four stages: *aggregate*, *remix*, *repurpose*, and *feed forward*. To *aggregate*, learners should build reliable connections with useful resources. In the *remixing* stage, learners should see the whole picture and rearrange its parts in order to serve their own perspective. In the *repurpose* stage, learners are expected to build something from the information that they have collected and rearranged. Finally, in the *feed forward* stage, learners are encouraged to share and discuss their work with other people.

Connectivism has been criticized since its emergence. Verhagen (2006) argued that a learning theory should address *how* learning occurs but Connectivism focuses on *what* is being learned. He added that Connectivism's principles add nothing new to the already existing base of knowledge and its principles have already circulated in the educational field long before its emergence. Verhagen (2006) also criticized Connectivism's principles since they are not written in such a way that can be tested. Furthermore, he questioned the validity of the principle that non-human appliances can learn, emphasizing the idea that machine learning has nothing to do with human learning. Bell (2011) argued that Connectivism proponents do not provide a consistent view of a theory. Kop and Hill (2008) added that any new theory should be built on former theories, not by discarding them. Connectivists, however, claim that it is not necessary to develop this theory based on other learning theories. In addition, Kop and Hill (2008) indicated that Connectivism is lacking sufficient empirical research. More recently, Clarà and Barberà (2014) identified three problems with the connectivist conception of learning. First, Connectivism does not present a solution for the learning paradox (how a pattern is recognized). Second, it under-conceptualizes human interaction by reducing a humanistic relationship to a dichotomous connection between two nodes (1 = active, 0 = inactive). And finally, it cannot explain concept development.

Some of the criticisms of Connectivism have been discussed by Siemens and Downes (Kop & Hill, 2008; Siemens, 2006a) and some others have been refuted by Connectivism's proponents (AlDahdouh, 2017; AlDahdouh et al., 2015). For example, in response to Clarà and Barberà's (2014) critique that Connectivism underestimates human relationships and reduces them to mere connections between nodes, AlDahdouh et al. (2015) showed that a connection in the knowledge network is graded and interpreted, which means that this connection can be as simple as a quantitative relationship (e.g. >, <, =) or as complex as a friendship between two individuals. In his later work, AlDahdouh (2017) made a comparison between the assumptions of Connectivism and the artificial neural network program, one of the leading software programs in the field of machine learning. The results of his study showed that artificial intelligence programs are capable of learning and they learn in similar ways as humans do.

Methodology

Participants

Based on recommendations found in scientific literature (Byrd, 2016; Conole, de Laat, Dillon, & Darby, 2008; Dujardin, 2009; Limbu & Markauskaite, 2015; Sharpe & Benfield, 2012; Symeonides & Childs, 2015; Zhang & Kenny, 2010), this study sought to recruit informative participants, from the Gaza Strip, who are willing to generate rich information about the phenomenon. The participants were recruited with the help of two instructors working at Palestinian universities. Four conditions were used to include participants in the study: he/she should (1) be a registered student at a Palestinian university, (2) be able to access the internet and to record his/her activities using different technological tools, (3) be willing to dedicate his/her time to solve tasks in the experiment, and (4) intend to share his/her learning processes with the researcher. Fifteen Palestinian students accepted the informed consent terms (Table 1 shows a list of participants), and of whom nine completed the ten tasks of the experiment. Data generated from only those nine participants were included in the analysis. Each participant received a monetary gratification (about US$26) upon completing the tasks. The final sample includes two males and seven females.

Since the experiment imposed no constraints on the amount of time needed to solve the tasks, there was a large variety among the participants, as seen in the 'Length' column in Table 1. For example, Redaa needed 24 days while Khaled W. needed 194 days.

Data collection tools

Each participant was asked to solve 10 tasks sequentially, one task after another. While searching for solutions, the participants were instructed to record their activities in different ways. If a participant chose to search on the internet, for example, he/she should record a video from his/her desktop. However, if the participant preferred to ask his/her friend via Facebook, he/she should copy and forward the conversation to the researcher. For any conversation involving other parties, a secondary informed consent was signed so that the conversation could be included in the analysis. The participants completed an online retrospective think-aloud (RTA) session immediately after finishing each task. In the RTA sessions, the participants were asked to watch the recordings of their activities and to report whatever was on their mind while performing those activities (Kuusela & Paul, 2000; Van Den Haak, De Jong, & Schellens, 2004). Each RTA session was also video recorded.

The tasks of the experiment were categorized based on their expected difficulty for the participants and the level of difficulty increased with each task (Q). The tasks in order were: (1) an information search, (2) the investigation of a person, (3) a question

Table 1 Participants information

Name[a]	Gender	Age	Field of Study	GPA[b]	Tasks Completed[c]	Length (in days)
Weaam	F	22	Pharmacy	87.95	10	30
M. AbuNour	M	20	Public Relations	76.20	1	46
K. AbuNour	M		Information Security		0	0
Khaled W.	M	21	Share'a and Law	76.80	10	194
Khaled D.	M	19	Journalism	81.50	10	183
Talla	F	19	English Literature	82.70	10	87
Sabha	F	21	Education	85.50	10	82
M. Musharawi	M		Share'a and Law		0	8
Redaa	F	20	Science Education	93.6	10	24
Salwa	F		Science Education		0	31
Neran	F	21	Math Education	80.74	10	37
Khoula	F	21	Math Education	82.00	0	7
Nawal	F	28	Arabic Literature	93.25	10	51
Khaled A.	M		English Literature		0	11
Amal	F	21	Math Education	80.50	10	42

[a]All names used are pseudonyms
[b]GPA stands for Grade Point Average (in percentage)
[c]Only participants who completed 10 tasks were included in the analysis

in their field of study, (4) a self-motivation question, (5) information validation, (6) a compound task, (7) writing an essay, (8) a design question, (9) a creativity question, and (10) a technical question. In Q02, for example, the participants were asked to search for information on a specific Palestinian character (a television actor or a social activist) and to create a complete profile for him/her. Participants were informed that plenty of information already existed on the internet about this character and that the participants should be critical of that information. The participants were also asked to build their own personal opinions about the character. Another example of a task in the experiment is the compound question (Q06), in which the participants were asked to apply for a specific scholarship (e.g. Search for 'Hani Qaddumi Scholarship Foundation'. Prepare your files to apply for a scholarship to cover your tuition fees for the next year.) This task involves sub-tasks such as writing essays, filling out application forms, and gathering other information for the scholarship.

Analysis

The literature in Connectivism concentrates on three broad categorizations of learning networks: neural, conceptual, and external (Siemens & Tittenberger, 2009). We limited this study to the analysis of conceptual and external networks, hereafter referred to as 'internal' and 'external' respectively.

The participants were asked to disclose the sequence of activities they followed in order to solve any given task at the beginning of each RTA session. For example, the sequence could be first asking a friend on Facebook, then searching the internet, and finally asking a teacher face-to-face. These sequences were stored in separate Microsoft Word files. There were 90 sequence files in total, since there were nine participants who were given 10 tasks each. The average number of steps per task was 4.82 and the range was 1–16 steps. Visual inspection of participant's steps was conducted. The visual inspection of sequences is well documented in the literature (AlDahdouh, 2018) but for this study only a general summary of the steps is reported.

Data for conducting qualitative content analysis included the video recordings of RTA sessions along with all other documented activities of the participants (e.g. Facebook conversations with friends, Face-to-Face recordings with relatives, and diaries recording the hard-copy materials used). ATLAS.ti 7 was also used in the data analysis.

Results

Throughout the course of the experiment, the participants engaged in a broad spectrum of learning activities and contacted various node types, as summarized in Table 2. The table was built based on the steps used in solving the tasks, as reported by the participants.

Connection forming

Even though there were many nodes that can be connected, as shown in Table 2, the behaviour and the verbal statements of participants indicated few determinant factors, which influenced the direction of their learning. The interpretation of these factors is anchored in the work of Bandura (1999, 2006), Vermunt (1998), Vermunt & Verloop, 1999), as well as the connectivist theorists, Siemens (2005, 2006b) and Downes (2008a,

Table 2 Learning nodes[a]

Internal (80)	Cognitive processes (34)			
	Writing (46)			
External (347)	Internet Search (169)	Laptop or Desktop (133)		
		Mobile (36)		
	Ask People (139)	Face-to-Face (48)	Friends (9)	
			Family members (26)	
			Teachers (13)	
		Online (91)	Email (2)	
			WhatsApp (10)	Friends (9)
				Teacher (1)
			Facebook Messenger (57)	Researcher (6)
				Friends (26)
				Family members (7)
				Teachers (18)
			Facebook Groups/Pages (19)	
			Skype call (3)	
	Paper resource (30)			
	Digital Resource (9)			
Give up (7)				

[a]The numbers in parentheses refer to the number of times a node occurred

2008b). The interpretation is also based on the author's understanding of connectivity theory which has been detailed in other works (AlDahdouh, 2017; AlDahdouh et al., 2015).

How a learner forms connection to a node can be summarized into three consecutive stages: (1) planning and forethought; (2) cognitive processing; (3) evaluating.

In the *planning and forethought* stage, the learner starts thinking and planning, but the goal is not to solve the task itself. Instead, the goal is to discover possible paths to the solution. This level of thinking and planning does not actually reside at the same level as the processes involved in the resolution of the task itself. In the experiment, when participants got their tasks, they usually started to mention some possible nodes (e.g. books, friends, websites, him/herself, teachers) that they might use to solve the task. Then, the participants usually eliminated and ordered the list of nodes based on their perceptions about each node. For example, in most cases, when the participants were asked to give reasons why they selected their chosen resource, they actually provided their perceptions of that resource. The planning phase was analysed further and is detailed in the next section.

The second stage of forming connections to a node is *cognitive processing,* which includes the process of interacting with the selected node. If the learner selected a book in the planning stage, for instance, he/she starts reading and understanding at this stage. If he/she selected a person to communicate with, he/she initiates a discussion with him/her at this stage. Cognitive processing refers to thinking activities learners use to find a solution for a given task. One could say that if the aim of the planning stage is to produce a learning plan, then the aim of cognitive processing stage is to execute the *first* step of the plan. In this experiment, cognitive processing involved interacting with the first node only because the participants did not complete what they had initially planned for in the first planning stage. Instead, their next nodes were mainly a result of another phase of planning, which occurred after evaluating the current node (see Fig. 1). The cognitive processing stage often takes longer than the other two stages.

In the *evaluating stage*, learners build their own theory about the node, based on the interaction with the selected node. The evaluation stage is based on the interaction with the selected node, but it is not part of it. The evaluation stage refers to the process of monitoring the value of the interaction with the node. Learners in this stage usually ask questions such as *What am I doing? Should I proceed with this node? Do I get what I want from here?* The following excerpt of Amal for Q09 – after spending some time searching the internet with no results – clarifies the evaluation process thoroughly:

> Amal: [long period of silence while clicking on the next page of searching results]
>
> Researcher: Please tell me what was in your mind.
>
> Amal: Actually, at that moment, I wasn't looking at those links [the searching result on the screen], not even one of them; I was thinking if I should proceed like this. What are you doing [Talking to herself]? Go and think of other option.
>
> Researcher: Aha.
>
> Amal: I wasn't convinced so much of what I am doing. I thought it was unlikely that this [search] would give me a result. It is not even logical to continue in that way. It is like finding a needle in a haystack.

The learner decides to stay or to leave the node during the evaluating stage. If the learner has decided to leave the node, typically the next step is to search for another node to connect to. The decision of leaving the node resides in the evaluation stage but searching for alternative nodes resides in the next planning phase (see Fig. 1).

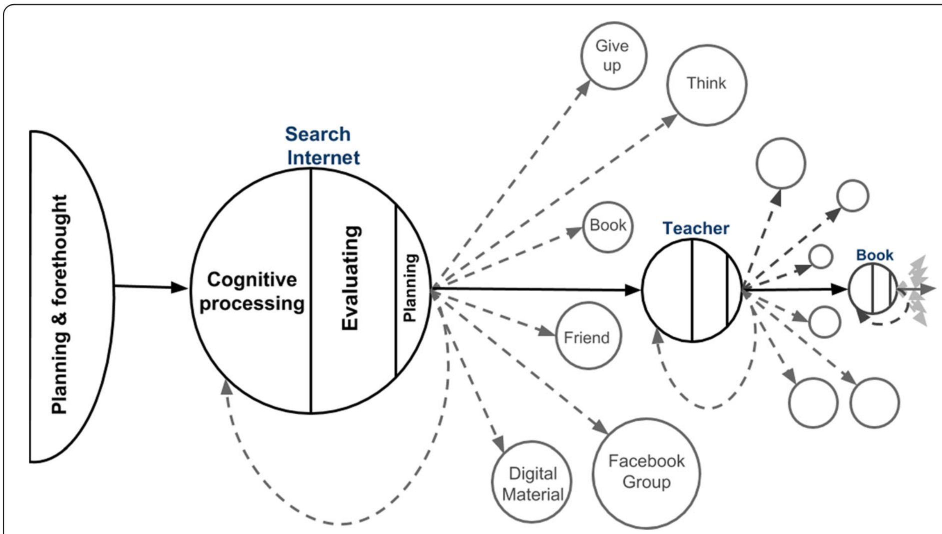

Fig. 1 Connection forming model

These consecutive phases ensure a chaotic characteristic of knowledge as described in Connectivism's literature (AlDahdouh et al., 2015; Siemens, 2006b). However, consistent patterns among participants and among questions do exist and can be investigated using quantitative (Macindoe & Abbott, 2004) or qualitative sequence analysis (AlDahdouh, 2018). Qualitative analysis of the patterns in learning experiences will be reported in a separate work.

Planning and forethought stage

Why participants tended to select a specific node was answered by their perceptions about the node. Qualitative data analysis revealed that there are three main perceptions that determine the participants' choices: (1) Self-efficacy, (2) Eligibility of the Resource, and (3) Feasibility of the Resource, as shown in Table 3.

Self-efficacy

Bandura (1988, 1989) identified self-efficacy as referring to one's belief in his/her capabilities to exercise control over events and to produce desired outputs. These beliefs determine the individual's behaviour. Pajares and Miller (1994) clarified that self-efficacy should not be mistaken for self-confidence. Self-efficacy is context-specific: a perceived ability to do a given task in a specific situation. In the experiment, self-efficacy seems to have played a pivotal role in determining one's self as a potential resource to solve the tasks. Thus, participants who strongly believed in their capabilities to achieve the desired output tended to include themselves on the list of resources to solve a given task. It is worth noting that those who had high self-efficacy considered themselves as one of many possible ways to solve the task, but that does not mean that they counted on themselves as the only way to solve the task. In contrast, participants who doubted their capabilities tended to overlook themselves as one of the available resources to solve a given task. The following excerpt of Talla, in Q09, clarifies how she eliminated herself as a potential resource to solve the task.

> Talla: But the thing [the task] is very hard for me. I can't solve it.
>
> Researcher: I would like to remind you again, there is no constraints on how you solve the task. All doors are opened for you. You can refer to any resource you wish.
>
> Talla: Of course, I am going to ask someone else but if I am going to cover all [missing] text myself, it would be very difficult.

Table 3 Criteria for selecting nodes

Self-Efficacy	Eligibility	Feasibility
High Self-efficacy	Authority	Ease of Use
Low Self-Efficacy	Recommended Resource	Relatedness
	Usefulness	
	potentiality	
	Remaining Resource	

Talla handed Q09 to her aunt and superficially participated in writing the solution. However, Talla, in Q07, depended on herself and completed the task without even referring to other resources as shown in the excerpt below.

> Researcher: I want you to tell me in more detail. When you started writing, haven't you think to gather information from the internet or other resources? Or have you just been satisfied with your personal experience?
>
> Talla: Yes, I was satisfied with my own experience and it is also because I have long experience in writing [similar topics]. So, I have good information about the subject.

The big difference between Talla's perceptions of herself in both tasks emphasized that self-efficacy is context-specific (Pajares & Miller, 1994). In addition, Bandura (1988) identified that self-efficacy is mainly developed through modelling, practicing under supervision, and independent work that leads to success. It was clear that Talla's self-efficacy, seen in her work on Q07, has developed through previous successful experiences.

In the experiment, all participants tended to declare their low, rather than their high self-efficacy beliefs. In simple tasks (Q01 and Q02), the participants usually finished the tasks without declaring their perceptions or their beliefs regarding their capability to solve these tasks, while the role of self-efficacy was evidenced in their reflections regarding the resolution of what they perceived as complex tasks, namely Q09 and Q10.

Eligibility of the resource

The second most important perception in determining the node selection was *the eligibility of the resource*. Eligibility of the resource refers to the degree to which a person believes that a node has the information needed or has the ability to solve the task. Both the self-efficacy and eligibility dimensions are two sides of the same coin, as both are referring to the nodes' ability to achieve the task. However, the node in the self-efficacy dimension refers to oneself while the node in eligibility refers to other resources. According to participants' statements, the eligibility dimension was graded from very strong to very weak. It is important to note that the categorization of the eligibility dimension is superficial and categorization was done using points on a continuum scale. Furthermore, it was difficult to decide if the participants' behaviour in the experiment was referring to one category and not the others.

However, based on the participants' testimonies in the experiment, the eligibility dimension was categorized into five categories ranging from very strong (Authority of the Resource) to very weak (Remaining Resource).

In the *Authority of the Resource* category, the participants believed that the node *certainly* had the needed information. According to the participants' perception, the node is the one, and perhaps the only one, which is *authorized* to provide the information. An example of such a belief was the tendency for the participants to communicate with and to get the information from the Palestinian character directly in Q02. In this question, five of the participants (Weaam, Khaled D., Sabha, Neran, and Amal) tried to send a message to the Palestinian character asking him/her to provide information about him/herself because he/she – as they justified – is the best one to talk about him/herself; ("If he can't, then who can?"). Data showed that the stronger a participant believed in the authority of the resource, the more frequently the participant referred to it over and over again; and the more likely the participant was to eliminate other resources from his/her account. Additionally, the failure of the authorized resource to provide the expected results had a significant impact on the participants' behaviour. For example, Neran, in Q10, handed the question to her cousin because she is a 'computer engineer'. Neran strongly perceived that her cousin is the one who should solve the task. When her cousin failed to solve the task, and indicated that it is very hard, Neran stopped working on the task. In Neran's words: "If the engineers couldn't solve it, can I?"

Recommended Resource is closely related to the Authority of the Resource category. Participants sometimes referred to nodes because other people recommended them. The participants did not build their initial views or perceptions about those resources on their own. When other people recommended the resources, however, they began to believe that the solution was there. Some participants took the recommendation seriously and stuck to the resource as if it were an authorized source. They tended to repeat the content several times and got frustrated when it did not work for them. Other participants saw the recommendation as a hint for useful resources.

In the *Usefulness of the Resource* category, participants believed that the node *most likely* had the needed information. The participants usually built their assumptions about the node's usefulness based on their own previous experiences. So, if the node, as perceived by the participants, has proven to be useful in similar tasks in the past, why not this time? In comparison to the Authority of the Resource, participants did not limit their choices to the resources they perceived as useful. Nor did they experience high-levels of negative feelings when they did not come up with the expected results. For example, Nawal, in Q10, justified her selection of a book by saying:

> Nawal: The book was in my own library and I studied it previously [at university]. I went directly to the chapter in which I thought the information most probably would be. I found some names there.

Potentiality of the Resource refers to the perception that a resource most likely will *not* contain the needed information. Even though the node, as perceived by the participants, most likely did not contain the information, there was still a little hope, which made them 'try'. The following excerpt of Weaam's reflections on Q07 clarifies how she consulted the internet, while she did not really expect to get results out from it.

> Weaam: Here, I wasn't really convinced when I was writing the keywords – 'writing scientific article about citrus: benefits and harmful effects' [the text she put in the search text box]. I mean, I wasn't convinced that I will find what I was searching for; I was just trying.

At the bottom of eligibility dimension resides the *Remaining Resource* perception. In the experiment, the participants referred to some resources that they previously eliminated from their account. By consulting those resources, the participants did not actually exercise their freedom to choose the node. They felt as if they were forced to consult the node because it was the only remaining resource available to them. Typically, the participants tended to refer to the remaining resource after a sequence of failures to extract the information from authorized, recommended, useful, and/or potential resources. An example is Sabha' perception in Q09. At the beginning of her process to solve the task she searched the internet, asked her friends, and tried to communicate with her brother. At the end, she felt that there was no option left for her but to write the solution herself. She brought a piece of paper and began to write. In her words:

> Sabha: My friend left me alone. She told me: "Proceed by yourself". But I felt that it is very hard for me. Anyway, at night, I wrote the shown parts of the story on paper.
>
> Researcher: Can you tell me how you wrote it? I mean, did you open your laptop to copy the story?
>
> Sabha: No, I copied it from my mobile. I began to write. And then, my brother came back home and saved me.

It is clear from the previous excerpt that consulting the remaining resource is accompanied by negative emotions. In the case of Sabha, her brother 'saved' her. The choice of the word 'saved' is clear evidence of how she felt when she consulted the remaining option, which was writing on her own.

Feasibility of the resource

Amongst the participants, the Feasibility of the Resource category is considered as the third main perception in determining the node selection (see Table 3). Feasibility refers to the degree to which the participants perceived the node as reachable. According to the participants' testimonies, it is not enough that one believes that the node is eligible to solve the task; it is also necessary to perceive that the node is reachable. In the experiment, the participants put feasibility of the resource as a pre-condition to its eligibility, but not the other way around. In contrast, the participants tended to eliminate some perceived authorized resources because they were not feasible. Neran, for example, in Q09, articulated her perceptions about the academics' cooperation, as shown in the following quote:

> Neran: I was thinking to visit the academics in Arabic Literature department in regarding the question but [in a weak voice] I eventually decided not to go.
>
> Researcher: Why did you decide that? Is it because you didn't have enough time or because the librarian didn't help you [in the previous step]?
>
> Neran: Oh, umm… [pause]
>
> Researcher: Don't be afraid, I am here to listen.
>
> Neran: Actually, I have a perception that academics are not cooperative. I am sure they would have known the answer if I had a chance to ask them, but they will not cooperate with me, I know.

Based on the experiment data, the Feasibility of the Resource dimension was divided into two categories: *Ease of Use* and *Relatedness*. Mainly, Ease of Use refers to the feasibility of things (e.g. mobile applications, internet, books) and Relatedness refers to the feasibility of people (e.g. teachers, friends, relatives).

Discussion and conclusions

Connectivism defines learning as the process of connecting valuable nodes in learning networks (AlDahdouh, 2017; AlDahdouh et al., 2015; Downes, 2006; Siemens, 2005). Previous studies evaluating the theoretical foundations of Connectivism, however, have noted that presentation of how the connection is formed is unclear (AlDahdouh et al., 2015; Clarà & Barberà, 2014; Dunaway, 2011). The aim of this study was to assess the process of navigating learning networks by tracking the learning process of nine students who were solving 10 tasks each. The most obvious finding to emerge from the analysis is that the navigation process is governed by three consecutive stages: planning, cognitive processing, and evaluation. The cyclic movement of these stages ensures the chaotic navigation between the nodes in learning networks.

The analysis revealed that the participants applied three perceptions about the node to decide whether to connect to it: self-efficacy, eligibility of the resource, and feasibility of the resource. Self-efficacy was shown to be important to the inclusion of oneself as a potential resource while eligibility and feasibility of the resource govern whether one would contact external resources or not. The data also showed that feasibility of the resource is considered as a prerequisite to its eligibility.

The planning and forethought stage is seen here as a part of the student's Meta-Cognition regulation processes. Vermunt and Verloop (1999) classified *orienting and planning* processes as the first component of Meta-Cognition regulation activities, which are defined as "those thinking activities students use to decide on learning contents, to exert control over their processing and affective activities and to steer the course and outcomes of their learning" (p. 259). Bandura (2006) specified four core principles of human agency, which distinguish humans from automatons. *Forethought* – one of those core principles – includes setting goals and anticipating likely outcomes of possible actions (Bandura, 2006, p. 164). The planning and forethought stage is also congruent with connectivist perspectives in that it sees all kinds of resources as nodes in which a learner is seeking to contact (AlDahdouh, 2017; AlDahdouh et al., 2015). In addition, one of the connectivist principles states that:

> "Decision-making is itself a learning process. Choosing what to learn and the meaning of incoming information is seen through the lens of a shifting reality. While there is a right answer now, it may be wrong tomorrow due to alterations in the information climate affecting the decision" (Siemens, 2005, p. 4).

Siemens (2005) also classified planning and forethought processes as Meta-Cognition skills in that he affirmed "The need to evaluate the worthiness of learning something is a meta-skill that is applied before learning itself begins" (p. 2).

Although there is a proliferation of literature indicating the importance of the planning phase (AlDahdouh et al., 2015; Bandura, 2006; Siemens, 2005; Vermunt, 1998), the current study shows their deficiency in clarifying the right methodology to elicit the mechanisms of planning utilized by the learners. Asking the participants explicitly to disclose the reasons for their choices, or instructing them to spell out whatever comes to their mind, with minimal intervention on the part of the researcher, – as recommended by the think-aloud protocol theorists, Ericsson and Simon (1980) – did not help in depicting the whole picture around the decision making on the part of the learner. The decision of selecting a given node in the learning networks involves a trade-off between different nodes and this trade-off does not appear on its own as stated by think-aloud protocols. Or it may be that the verbal reports provided by the participants in this experiment were too fragmented which made it very difficult to reconstruct their thoughts (Ericsson, 2003; Ericsson & Simon, 1980, 1998). The following excerpt of Amal in Q07 clarifies how she made a trade-off between two competing nodes.

> Researcher: Ok, after you went to your professor and she recommended you borrow a book from the university's library, what did you do?
>
> Amal: I thought to follow her recommendation, but I changed my mind. I remembered that [paper] books are not easy to copy from. If I found the right book, should I copy the text by hand?
>
> Researcher: Aha.
>
> Amal: So, I decided to search for eBooks instead. eBooks are easy to search and easy to copy-and-paste from.

In this excerpt, Amal eliminated paper books because she perceived them as hard to copy from, and chose digital books instead because she perceived them as easy to search and copy from. Concentrating solely on why Amal chose the digital resource (ease of use) diminishes the opportunity to understand why she eliminated the paper resource (hard of use). Her decision was, in fact, a combination of her perceptions of all possible nodes (the ease of e-book, the hardness of paper book, and maybe undeclared perceptions about other nodes). Of special note here is that the participants hold two kinds of perceptions about any node: one that is manifested as the reason for choosing the node, and the other is manifested as the reason for excluding the node. The factors reported earlier in the current study show only half of the story: *why* the participants in this experiment selected each node. However, for a broader picture, future studies should ask the participants both why and *why not* they selected each node.

In summary according to the results of this study, the planning stage includes the following main points:

- The number of nodes surrounding someone limits or increases his/her potential choices.
- The previous assumptions or perceptions about each node determine if one is going to include or exclude the node from his/her choices.
- Three main assumptions were reported as the main factors steering the learner's choice of nodes in the learning networks: self-efficacy, eligibility, and feasibility of the resource.
- The reasons why a node is selected do not inform us of why the node is not selected.

- Returning to the same node is a possible choice, depending on one's perceptions about the node.
- The planning process is one of the students' Meta-Cognition activities.

An often-overlooked stage in the process of forming connections is the evaluation stage. This kind of self-awareness of actions helps the learners judge the value of the node and redirect their learning path. Vermunt and Verloop (1999) classified the evaluation process as part of students' Meta-Cognition regulation activities and defined it as "observing, during task performance, whether the learning process proceeds according to plan" (p. 262). Bandura (2006) identified the evaluation process as self-reflectiveness, the fourth core principle of human agency. He clarified that "the metacognitive capability to reflect upon oneself and the adequacy of one's thoughts and actions is the most distinctly human core property of agency" (p. 165). Connectivism literature, it appears, does not pay considerable attention to the evaluation stage. Instead, the main attention has been paid to the planning and forethought stage. The results of this study showed that the evaluation stage is no less important than the planning stage and should be considered as one of the key learning processes in the connectivist environment. Failure in the planning process might lead learners to visit unrelated nodes, but failure in the evaluation process would make the learners delve into them.

Findings from this current study provides some support for the conceptual premise of Connectivism. Conceiving knowledge as having a network structure and perceiving learning as a process of navigating this network sufficiently, simplifies the complexity of the human learning process. Though Connectivism has yet to recognize how learners form connections to the variety of resources, this current paper sheds light on this important topic and has provided a framework which may be useful to other interested researchers in studying the learning network phenomenon. For practitioners and educators in the online learning field, the findings have important implications for developing their practices. Practitioners should be aware of the criteria used by their students in choosing from the available nodes. For example, educators who are keen to encourage their students to count on themselves while solving specific academic tasks, should exploit the role of self-efficacy to include/exclude oneself from the potential resources.

In addition to the methodological limitation outlined previously, the small sample size was a main weakness of this study, which limits the generalizability of the results. Another source of weakness was the scope of the analysis, which focused on the planning phase but not on other essential phases, namely the evaluation phase. Those are important issues for future research. Despite its limitations, the study adds to our understanding of how learning proceeds in learning networks from the students' perspective.

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Authors' contributions
The author read and approved the final manuscript.

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